

CHEMICAL & METALLURGICAL ENGINEERING

VOLUME 41 ESTABLISHED 1902 NUMBER 10

MCGRAW-HILL PUBLISHING COMPANY, INC

S. D. KIRKPATRICK, Editor

OCTOBER, 1934

PARALLEL PATHS OF PROGRESS

TWO COURSES lay open to the editors in planning this sixth Materials of Construction issue of *Chem. & Met.* The first was to continue, as in the past, to secure from the manufacturers the latest information regarding new products or newly discovered uses for older materials. In a period of rapid change and development, this procedure seemed essential if the chemical engineering reader is to be kept informed of progress. Yet at times it must be admitted that such news may appear confusing and conflicting. It often lacks critical interpretation because the natural enthusiasm of the maker cannot help but be reflected in his optimistic recommendations.

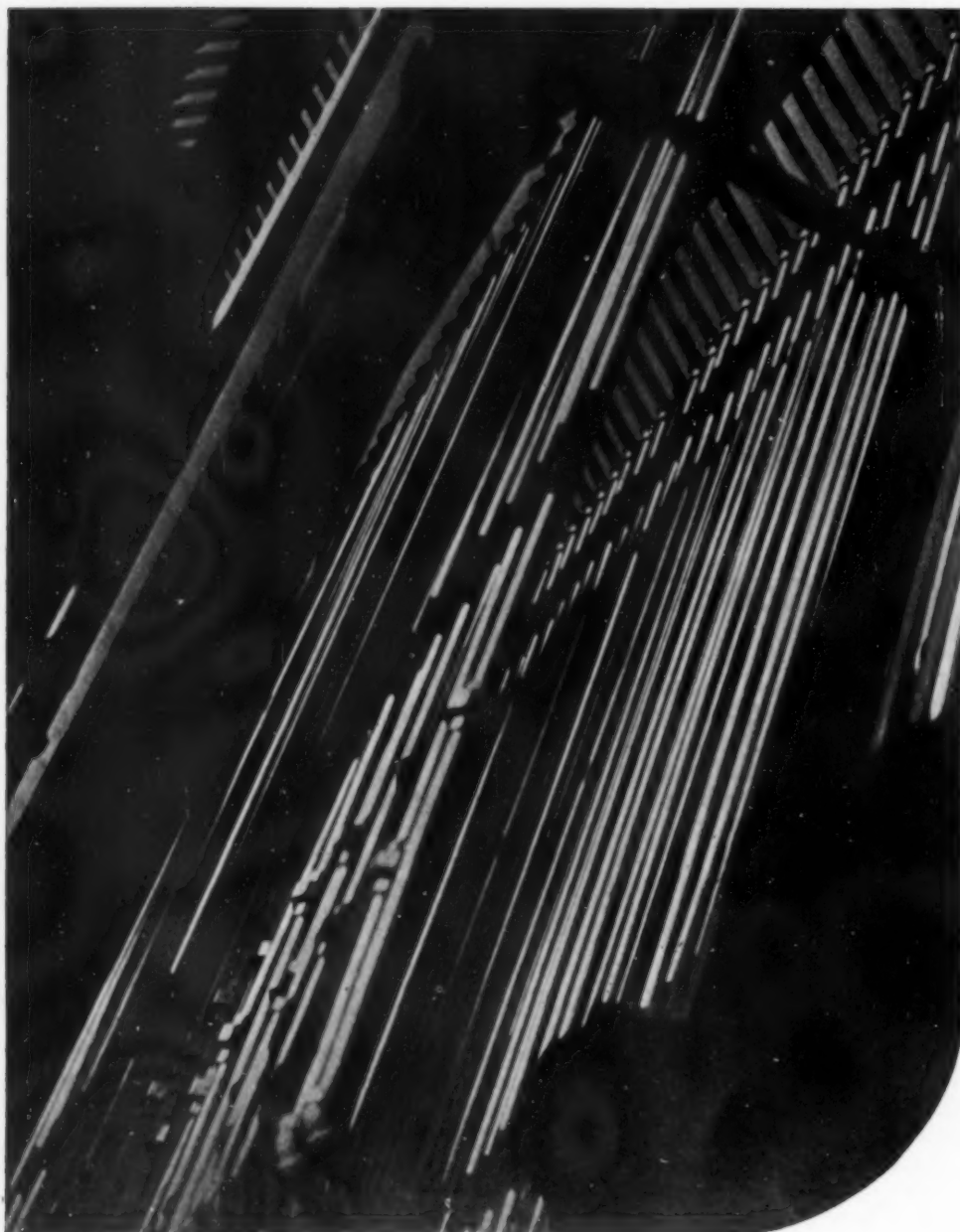
The second course is to turn to the user—the man who employs these materials in process equipment and plant construction. Surely such experience, based on actual performance records, should prove a safe guide as to standard practice in our various industries. Yet it, too, has its limitations in the very conservatism with which the user is willing to share his experience. Forgetting for the moment the element of secrecy that would have made such a program impossible ten years ago, it is difficult for any individual to report other than his own narrow field of activity. He becomes cautious and hesitates to pass judgment on what he may call “experimental” materials. The result too often is lacking in the imagination and speculation that stimulate further advance.

To steer a middle course between maker and user of materials would be to stick to the common ground of agreement which, although impartial and authoritative, must again be colorless and uninteresting. So *Chem. & Met.* in this issue refuses to follow any single path. Rather, we take the reader on some novel

excursions along the chemical engineering highways and byways of both the consumer and the producer. There is much to learn from each. Standard practice with construction materials is of most value to young engineers and others who seek authentic advice based on years of experience. On the other hand, we can have real progress only when the user is willing to share with the maker in his attempts to develop new and improved materials to meet new and more severe requirements of process industries.

The articles of this issue reflect, from a wide variety of sources, the striking progress of recent years. Some fifty outstanding chemical engineers state the corrosion problems and the remedies employed in as many different industries. Another editorial supplement, the third in our 1934 series of *Chem. & Met. Data Sheets*, cites standard practice in the use of construction materials in our field. Thus is the Chemical Engineering File that we began in January with economic and statistical data, followed in May with the flow sheets and raw material requirements, now rounded out toward completion. Finally, from the makers comes the Directory of Materials which lists the names, compositions and manufacturers of all of the metals, alloys and non-metallic materials of construction used for corrosion, heat and abrasion resistance.

Here is indeed another and striking measure of the rapid progress in this field. From 75 listings in 1924, to 115 in 1929, to 250 in 1932, and now to more than 600 in 1934, proves that we are moving rapidly ahead. That progress will continue as the chemical engineer and the materials maker come to a realization that their paths are parallel—and their one objective, more efficient production at lower cost.



Photographs by Rittase, Philadelphia

Beyond

By

**HAROLD L.
MAXWELL**

*Chemical Engineer and Metallurgist,
Engineering Department,
Experimental Station,
E. I. duPont de Nemours & Co.
Wilmington, Del.*

The whole field of materials for the construction of chemical engineering equipment is passing through a transition, the significance of which most engineers and industrialists have failed to appreciate. Not only are such standard materials as cast iron and steel being subjected to changes by the addition of other elements, but even the much renowned chrome-nickel steels, which must still be looked upon as newcomers, are rapidly being modified in composition, properties and fields of usefulness. What the final result will be is anyone's guess.

Not even a Jules Verne could have visualized a few years ago that such materials as the synthetic resins, carbon, glass and silver

would be used so extensively for the construction of large-scale equipment. At present these metals and non-metals are finding important applications in a few of the most progressive plants—and to a far larger extent than most engineers are aware—but unfortunately information regarding their use is being carefully guarded for fear that others will discover their advantages.

The progress that is being made in the development of new materials and those that will be used in constructing equipment of the future are discussed in the accompanying article by Harold L. Maxwell, an authority on this important subject for our largest chemical manufacturing organization.—Editor.

Today's MATERIALS of Chemical Engineering

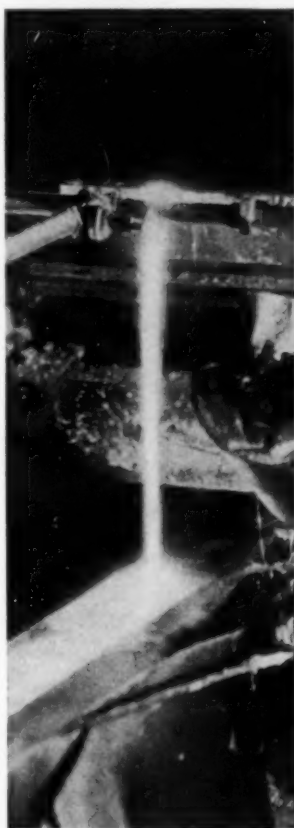
THE SELECTION of materials of construction for use in a wide variety of corrosive process conditions, together with the installation and following through of this equipment in plant use, has pointed out certain trends of wide interest to chemical engineers.

It is unnecessary to say that the practicability and success of a chemical enterprise, if not based entirely on, is largely influenced by the selection of equipment that will show maximum economies in operation. It is not enough to produce a commodity that will find a ready market. It is essential that this commodity be produced at a profit and herein lies the background against which we must reflect our decision in matters of selecting materials of construction, in order to obtain optimum returns for the equipment investment. Aside from the initial cost which too often receives undue consideration, there is the more important factor of "equipment cost per ton of product" which is determined by the extent of equipment life. And even these combined factors answer only a part of the equipment cost problem until we keep in the foreground the essential time element of how long the equipment will be needed. For instance, there is a process in which a rare metal will give a life of fifteen years and will show economies, provided the high initial cost and low maintenance can be distributed over the full anticipated life of fifteen years. Better economy results in this particular case from the use of a material showing six months' life, because of the probability that the process will be entirely changed within five years. There appears to be, therefore, three essential factors to consider in selecting materials of construction for process equipment: 1. Initial cost, 2. Potential life of equipment if continued in service, and 3. Permanency of process.

During the periods of highest production there was less concern felt for obtaining the maximum economic life from equipment. Furthermore, it is generally observed that the life of process equipment in continuous service in most chemical processes is usually greater than the same length of life resulting from intermittent service. One case in point, low alloy tubing in steam coil service under mildly corrosive conditions shows a substantially greater tonnage of product from continuous service than when in intermittent service.

Those who have been associated with the development and applications of chromium and also chromium-nickel alloys over the last fifteen years, find a definite trend in the reduction (some claim elimination) of difficulties resulting from carbide precipitate. The early alloys with 0.15 to 0.30 per cent carbon find limited use today, except in castings. What consultant is there who has not been confronted with requests to show how corrosion-resistant welds can be made of it? The tendency is unmistakably toward a carbon content of 0.07 maximum in the conventional 18-8 chrome-nickel alloys, with somewhat higher carbon permissible in certain metals of higher total alloy contents. Not satisfied with developing a corrosion-resistant alloy of low carbon content, further effort was extended through the addition of modifying elements to make the carbides less reactive and thereby reduce the necessity for heat treatment following welding. The introduction of the delta phase in stainless steels and the addition of columbium are among the latest innovations. Both have merit in specific cases and should be developed further.

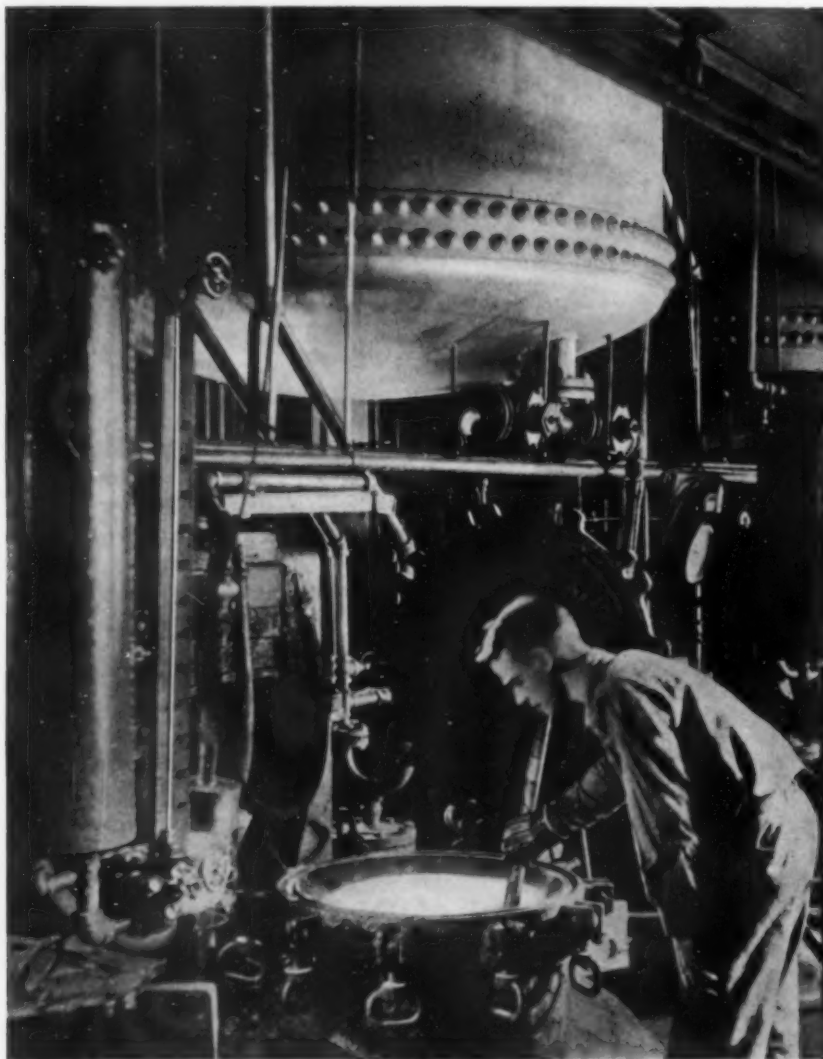
Weldability of chromium and chromium-nickel steels is now practically essential on all sheets and plates. The present trend is toward a highly resistant alloy that will not require



heat treatment after fabrication into process equipment.

The development of "ease of machining" in stainless alloys by the addition of a dispersed phase is well known. Opinion seems to be divided on just how much emphasis to place on the machining aspects of stainless steel, except in those cases where an automatic screw machine comes into the picture on the production of large numbers of small parts.

Until about 1920 cast iron was considered as a material with a narrow range of uses and of little flexibility in its application. Within the memory of most of us, it was not unusual to hear: "Why add an alloying metal at 35c per lb. to cast iron in order to improve its quality, when you can replace the cast iron equipment with a wholly new part at 3c per lb.?" There are numerous instances where low alloy cast iron has shown 500 per cent improvement in service life, at an increased cost of only 25 per cent. Conversely, it should be added that in some processes the use of low-alloy cast iron has resulted in shorter life than a regular gray cast iron which is procurable at a lower cost. Alloy additions to cast iron have shown, in general, some improvement, but it is by no means a "cure-all." Increased consideration is being given to cast iron for application in process equipment.



Cast iron cam shafts for internal combustion engines are now used. Furthermore, cast iron crank shafts are well past the experimental stage. Cast iron process reaction vessels are now operating continuously at 700 deg. C. under loads that would have been entirely impossible with the material known as "cast iron" in 1920. Cast iron deserves further development in its alloy modifications.

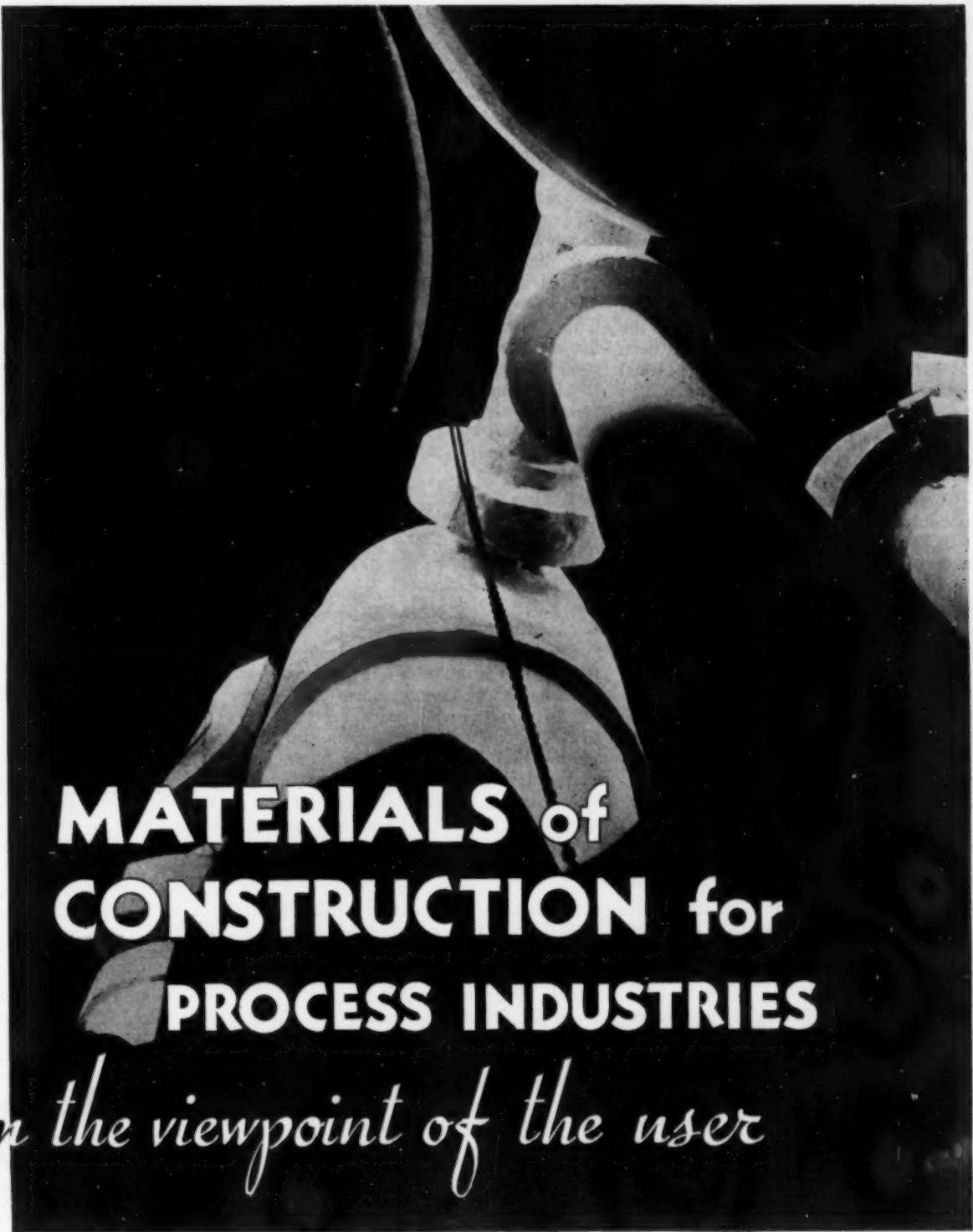
Organic plastics and surface coatings are finding increasing application in chemical plants. Many of the organic acids and the weaker inorganic acids and metal salts, that attack the lower cost alloys to a marked degree, are being successfully handled in non-metallic equipment. One of the factors limiting a much wider application of these materials is the temperature limitation.

The resistance of metals to high-temperature and high-pressure hydrogen, it will be recalled, was at first a problem of academic interest. Early researches were made on thin sheets of metals in order to develop information on the permeability of different metals to hydrogen under varying conditions of temperature and pressure. This problem developed a commercial application at the time of the initiation of oil hydrogenation on a commercial scale. The early developments of this

application required only a small quantity of equipment to withstand temperature and pressure, since the use at that time was limited to hydrogenation of edible fats. The whole problem now assumes much wider scope, due to increasing synthesis of organic acids and fuels by hydrogenation.

The synthesis of ammonia at high temperature and pressure is widely known and requires little further emphasis. The tendency in the early work in the development of materials to resist hydrogen and nitrogen was to find a material of low-alloy content that would be resistant to 300-400 atmospheres pressure, and the temperatures up to 300 deg. C. Whereas at present it is necessary to have a metal retain its physical properties after continued use at 15,000 lb. pressure, and at 500-600 deg. C.

Briefly summarizing, the present trend in the selection of materials of construction appears to be away from the excessively large installation of relatively lower-cost materials, and definitely toward the installation and maintenance of proportionately smaller sized units operating under more severe conditions of temperature, pressure and corrosion. This implies that in the future there will be demands made for materials to withstand increasingly severe operating conditions, and it is to be expected that some of the conventional alloys will undergo further modification from alloying elements to meet these requirements.



MATERIALS of CONSTRUCTION for PROCESS INDUSTRIES

from the viewpoint of the user

Nearly 40 production engineers whose contributions appear in the following pages, together with at least an equal number who cooperated in interviews or whose recent writings supplied necessary information, have made possible this alphabetical compilation of USER data on construction

materials. CHEM. & MET. asked these engineers, "What is the best of current practice in construction materials for x, for y, or for z?" Their answers, for more than three-score process industry products, are summarized in the 55 short articles which comprise the following section.

Acetic Acid

By T. C. ALBIN

*Chemical Engineer
Forest Products Chemical Co.
Memphis, Tenn.*

• **COPPER**, by and large, is the premier metal of the acetic acid industry. Aluminum is highly satisfactory, especially with strong acids, and so, of course, are stoneware and the high silicon irons when considered solely from the standpoint of corrosion. Nickel, Monel and the nickel chromium steels no doubt have their applications, but the fact remains that copper has long been the standard metal in the wood chemical industry. And since existing apparatus can usually be adapted with very little change for use in direct acetic acid recovery plants, copper is likely to continue to be favored over newer alloys.

Corrosion of copper by acetic acid can be controlled to a considerable extent. It is accelerated to a marked degree by the presence of air, as is evidenced by the fact that leaky apparatus is always short-lived. By the same token, the equipment used in a continuous process will last much longer than if used intermittently, as in a batch process.

The next most important factor affecting the corrosion of copper is its hardness, hence the once universal practice of "hand hammering" all copper equipment. To an unfortunate extent, however, that process is becoming a lost art, presumably because to most people it looks like an economic waste to allow a high-priced man, such as a coppersmith, to peck away for hours on a section of a distilling column after it is, to all appearances, completely fabricated. Our experience has shown that the hours spent in proper hammering give months of added service.

Annealed spots in copper equipment, where connections are brazed on without proper re-hammering, are attacked much more rapidly than is the surrounding hard metal. There is enough difference between the hard and soft copper to set up electrolysis with the result that the soft metal is dissolved and then deposited on the adjacent hard metal as firmly attached copper "warts." By giving thought to this feature in the design of equipment, the number of "soft spots" can often be reduced. In inaccessible places, where these soft spots cannot be reached with a hammer, a liberal coating of silver solder, extending well over onto the hard metal, will materially retard corrosion.

Although it conflicts to some extent with the corrosion tests reported by the bronze manufacturers, our general experience has been that copper is more

resistant than any of its alloys. However, phosphor bronze of a composition of 95 per cent Cu, 4.8 per cent Sn and 0.2 per cent P has been found quite satisfactory. It makes sound castings and is not difficult to machine. It may be brazed as easily as copper without developing shrinkage cracks on cooling. Thus it is very easy to repair phosphor bronze equipment by the same methods used on copper apparatus.

Aluminum is only slightly attacked by strong acetic acid. The rate is higher as

the dilution increases and is accelerated by impurities in the weak acid. The presence of air does not have the same adverse effect on aluminum that it has on copper. Accordingly, this metal is more satisfactory for product lines, blow cases, storage tanks and other equipment that is used intermittently. Under certain conditions there may be some electrolysis between aluminum and copper, but this has never been much of a problem in our plant. (Our most unfortunate experience with electrolysis has occurred when nickel alloys, including stainless steels, have been used in direct contact with copper.) The only difficulty encountered with aluminum has occurred where the local water caused pitting on the outside of the cooling coils and condenser tubes. Such cases are rare indeed and seldom a source of serious trouble to the acetic acid producer.

Acetic Anhydride

By D. F. OTHMER

*Department of Chemical Engineering
Polytechnic Institute of Brooklyn, N. Y.*

• **AS WITH MANY**—if not most—of the chemicals having a bad name for corrosive properties, with acetic anhydride the bad name comes from the company it keeps, i.e., impurities. The pure material, even with 15 per cent acetic acid which is the standard strength, may be handled in iron without serious corrosion. Where an absolutely water-white grade is needed, shipments are made in aluminum to prevent the rust or other contamination experienced with iron. This contamination may be due to the film produced by the "wash" of liquid inside a tank in shipping, which in contact with dampness from moist air reduces the strength of an infinitesimal fraction of the total shipment at a vulnerable point, to give acetic acid containing some water.

In the so called "chemical" processes for anhydride production, involving sodium acetate and sulphur chlorides or related materials, production is usually accomplished in cast-iron reaction vessels. Depending on the design of units, iron or steel distilling and drying equipment is used for removing the liquid from the large mass of salts remaining behind. As is usual in condenser and distilling equipment design, copper and bronze come into use for condensers, pipe lines, etc., for handling crude anhydride, and for steps in the several refining operations, although iron is also usable in most places.

The final operations and storage are usually in aluminum vessels because of

the entire absence of color which this metal gives to the finished product.

In the many vapor-phase and pyrogenic methods for production of the anhydride, chrome and nickel steels and other alloys are used for their resistance to the temperatures and pressures encountered, as well as chemical stability to the reactants. Several processes involving pyrolysis are negatively catalyzed by iron and nickel; and copper or bronze tubes and parts suitably shielded from the effects of heating have been recommended. The steps of purification and refining again use copper and aluminum in the same ways as do the "chemical" methods.

Acetone

By J. N. COMPTON

*Chemical Engineer, Carbide & Carbon
Chemicals Corporation, Charleston, W. Va.*

• **TO THE BEST** of my knowledge, acetone is without effect on any metal or other common material of construction, with the possible exception of certain plastics and other organic materials for which it is a solvent. From time to time long lists of expensive alloys have been proposed and recommended for use with acetone. These are not only useless but somewhat misleading because there is no corrosion

MATERIALS OF CONSTRUCTION

problem and the simplest, cheapest materials are satisfactory. The fact that one may use gold, platinum or any other precious metal for acetone piping may be technically correct, but the fact is of no interest whatsoever to an engineer when he knows that steel

piping is suitable. Copper is, of course, the usual standard material for fractionating columns and condensers and is, therefore, rather widely used in acetone production. So, too, are the bronze valves, cast iron pumps and other material used in this industry.

erations without difficulty. Groggins (*Trans. A.I.Ch.E.*, Vol. 25, p.159) also reports that large quantities have been stored at Edgewood Arsenal in properly sealed iron drums over a period of years, without deleterious effect either on the drums or their contents. His paper calls attention to a few simple precautions that should be observed in the use of aluminum chloride in industry.

In general, most reactions involving the use of aluminum chloride may be carried out without danger in iron or steel equipment, provided that there is no free or combined moisture present. When running intermittently, it is usually desirable to see that the equipment is flushed out after the last run with dry air or anhydrous solvent to remove the HCl. If these precautions are not observed, moisture is attracted by the deliquescent vapors with the result that the acid attacks the vent line and the sides of the reaction vessel.

Aluminum Chloride

EDITORIAL SUMMARY

• WHEN A. M. McAFEE, superintendent of the aluminum chloride department of the Gulf Refining Co., last reported on his process at the Philadelphia meeting of the American Institute of Chemical Engineers (see *Chem. & Met.*, July, 1929, p. 422-4), he told an intensely interesting story of a 15-year struggle with corrosion problems. His ultimate success in producing cheap anhydrous aluminum chloride was due largely to a change in the design of the condensers, into which the vapors pass from the furnace after the bauxite has been chlorinated. Since aluminum chloride passes from vapor directly to solid phase, it was early thought that these condensers must be very large in order to prevent stoppage; and because the aluminum chloride is corrosive at this stage in the manufacture, Mr. McAfee decided to build the condensers of brick. At one point of the development, these were huge tunnels, 30 ft. long, 12 ft. high and 6 ft. wide.

Today all of Gulf's aluminum chloride is condensed in 16-in. vertical iron tubes. Revolving steel shafts and blades inside these iron pipes knock down the aluminum chloride as fast as it is condensed. But what about the corrosion? Very much to Mr. McAfee's surprise, the life of one of the iron tube condensers is at least two years. Apparently the inside of the pipe quickly becomes coated with a thin layer of the anhydrous aluminum chloride and, despite the fact that free hydrochloric acid and often a trace of chlorine are present in the condenser, the coating seems to protect the iron from corrosion.

Another development that added to the life of the equipment was the insertion of a firebrick-lined cooler, between the furnace and the condenser. The chlorinating furnaces, 5 ft. in diameter and 20 ft. high, are lined with two courses of circular firebrick and behind these is a layer of bauxite encased in an iron jacket. The object of the powdered bauxite is to protect the iron from attack by the chlorine. Under present practice, Mr. McAfee reports that a lining is good for about 100 days.

Anhydrous aluminum chloride is

packed in iron drums which are eminently satisfactory as long as moisture is not allowed to come in contact with the salt. Then, of course, HCl is certain to be formed in quantities which no iron container can long endure. McAfee reports, however, that hundreds of tons have been shipped in inter-refinery op-

Aluminum Sulphate

By D. S. DINSMOOR

Superintendent, Merrimac Chemical Co.
Boston, Mass.

• MANUFACTURE of aluminum sulphate involves construction problems for which no completely satisfactory solution has yet been found. From the corrosion standpoint hard lead (6 per cent antimony) is very good for all strengths but its limitations with respect to erosion and crawling are well known. In spite of these limitations hard lead continues to be used all through the process as its first cost, and the fact that it can be continually patched and repaired, make it in general the most economical material for general purposes.

Duriron also seems to be satisfactory as far as corrosion is concerned and is used for valves and pumps. Materials satisfactory for sulphuric acid are not necessarily resistant to aluminum sulphate. For example, Pioneer alloy valves have been disappointing while, on the other hand, Pioneer shafts and impellers have done very well on pumps handling liquor and residues. Tellurium lead seems to have good possibilities but experimental installations have not as yet had sufficient test to determine how the life compares with antimonial lead. The chrome and nickel-chrome steels and the aluminum bronzes have no application. Durimet has a low corrosion rate and is now being compared with lead as a material for shafts and stirrers. Bronzes are attacked slowly and are used to a slight extent for fittings, particularly on weak liquors. Monel metal is about on

a par with Tobin bronze and is of course more expensive. Rubber is satisfactory within its usual limitations as to strength and temperature. Preliminary tests of silicon bronze samples look promising.

The hardest service encountered is in reaction agitators, particularly in the batch process where the cycle involves hot acid, strong boiling aluminum sulphate solutions and the erosion problem due to the necessity of keeping siliceous residues in suspension. To date the most satisfactory construction has been steel, lead lined, with an inner lining of acid-proof brick. With care in respect to detail of design this construction has fairly long life. Similar construction is quite satisfactory for settling tanks for strong solutions, while hard pine or cypress tanks are used for weaker solutions such as wash liquors.

Hard lead is mainly used for pipe lines, pumps and valves, though Duriron is increasing in use for these purposes

Evaporators have been the subject



FOR PROCESS INDUSTRIES

of considerable experiment and lead is still the most economical material. Acid-proof brick has been extensively tried but no brick has yet been found which will not spall and crack after a time. This is very bad as it introduces foreign material into the finished product. It is the writer's opinion that so-called bonded lead should be the ultimate solution but so far no maker has furnished a bonded lead which was satisfactory.

Tellurium lead is now being tried in this apparatus.

Steel cooling floors are satisfactory for all ordinary purposes. Staining of the iron-free product can be avoided by cooling on a bed of ground sulphate. Concrete, brick and lead have been found unsatisfactory.

With regard to pulverizing, conveying, screening and packing equipment, there is no corrosion problem.

Ammonia-Soda Alkalis

By L. C. HUGHES

*Consulting Chemical Engineer
Elizabeth, N. J.*

• **CAST IRON** is the principal metal used for process equipment in the production of soda ash, especially in the intermediate steps of the process where the metal comes into contact with the various ammoniacal liquors. After the sodium bicarbonate is precipitated and filtered, cast iron is not so essential, since the material is dry enough to be handled in ordinary steel equipment. It is a maxim in the alkali industry, however, that the use of cast iron wherever possible gives longer life to equipment. The ammoniacal liquors will attack cast iron to an appreciable extent, but ordinarily they offer no serious problem either as regards purity of finished product or rapid deterioration of equipment. They must be watched closely as to hydrogen-sulphide content, however, which is maintained at approximately 0.1 gram per liter in order that dissolved iron may be precipitated before the liquor is sent to the carbonators.

Considerable thought has been given to metals used in the heat recovery sections of the distiller, particularly in the part which consists at present of cast iron tubes through which the incoming liquor flows in order to cool the outgoing ammonia gas. Stainless steel tubes have been suggested for this purpose, but no application has been tried to the writer's definite knowledge. Some years ago one plant used aluminum tubes with some success, but water instead of incoming liquor served as the gas-cooling medium.

Stainless steel knives are used for cutting the bicarbonate from the rotary vacuum filters. The writer has used nickel-chromium wire instead of steel wire for holding the filter blankets and has found it more economical, as its longer life more than offsets the additional cost.

Since the commercial production of rayon demands a grade of caustic soda containing only traces of some of the

metallic impurities, it has been necessary for the alkali producer to adopt various metals or alloys not previously used. This was especially necessary in the case of electrolytic caustic soda since the presence of hypochlorites and salt in the liquor caused more corrosion of equipment and consequently more metal impurities in the final product. Prior to this demand on the part of the rayon producers, cast iron and steel were most

Ammonia

EDITORIAL SUMMARY

• **IN PRODUCING** ammonia from ammonia liquor there is no corrosion problem that cannot be met satisfactorily with iron and steel equipment. The only use of special alloys or other materials, so far as is known, occurs in the construction of valves which are of the iron body type with seats of iron, Monel metal or lead and stems of chrome-vanadium steel.

A distinct corrosion problem, however, occurs in the synthesis of ammonia, at points in the process where the temperature of the nitrogen-hydrogen mixture is sufficiently high to cause nitriding of the steel. Alloy steels have been used in an effort to avoid this, but it is reported that no thoroughly satisfactory solution has been found. On that account some authorities have concluded that the best procedure is to return to ordinary steel, replacing it as often as may be necessary. Certain of the stainless steels may be better, but they are not believed to be enough better to justify their greater cost.

In the main, standard construction is employed for most of the ammonia plant. Firebrick lining for the gas generator and checker chamber and ordinary low-

commonly used for caustic soda equipment, even to the extent that in some plants steel tubes were used in the evaporators. Other plants used copper tubes and, by the addition of a small amount of sodium sulphide as an inhibitor, were able to keep down corrosion to a minimum.

Monel metal tubes have also been used for some time. In recent years, however, nickel has become the most important metal used in the construction of caustic soda evaporators, as well as for other apparatus which comes into direct contact with hot concentrated caustic liquor. Evaporators are now constructed with cast iron bodies, cast iron tube sheets and nickel tubes. Some recent installations have steel bodies with an inner lining of nickel sheet which is bound by a special process to the steel when it is rolled. Special methods have been developed for welding the joints of this nickel-clad steel so that the interior of the evaporator is a continuous nickel surface.

Caustic pots for producing the solid product are made of cast iron containing nickel. The analysis of a good grade of cast iron for this purpose is as follows: carbon, 3.30; manganese, 0.50; silicon, 0.70; chromium, 0.60; and nickel, 1.50 per cent.

carbon steel for the towers and heat exchangers are satisfactory. The compressors are of standard construction for the pressures used. The water turbine used to regenerate part of the pumping power for the wash water in the CO₂ absorption tower is of bronze. The copper solution system for removal of the CO is all iron with ceramic or steel raschig-ring packing.

Forgings used in the converter are of chrome-nickel or chrome-vanadium steel, but low-carbon steel forgings are satisfactory elsewhere. For the cold gases ordinary steel pipe of proper strength is suitable.

Ammonium Nitrate

EDITORIAL SUMMARY

• **CORROSION** must be avoided in the manufacture of ammonium nitrate, not so much for the protection of the equipment as for the effect of the corrosion products on the finished material. Ammonium nitrate is, of course, an ingredient of explosives and has itself been involved in some unfortunate occurrences in this country and abroad (see article by Dr. Charles E. Munroe in *Chem. & Met.*, March 22, 1922).

It is not definitely known whether

MATERIALS OF CONSTRUCTION

copper corrosion products form sensitive compounds with ammonium nitrate or not, but they do lower the ignition point of such explosive mixtures as amatol. Hence copper, Monel metal, and the brasses and bronzes should not come into contact with the salt during any stage of its manufacture. Tin is also known to have a deleterious effect, perhaps forming a more sensitive salt, so it, too, must be avoided. Wood and aluminum remain the two materials most often recommended for handling ammonium nitrate in the final stages of mixing it with other explosive ingredients.

H. F. Whittaker reported to the

American Institute of Chemical Engineers (see *Trans. A.I.Ch.E.*, Vol. 15, Part 1, p. 126-7) that the evaporation of ammonium nitrate liquors formerly represented a serious problem because of the hydrolysis of the liquor to ammonia and nitric acid. The latter set up electrolytic corrosion between the cast iron vessel and the wrought iron steam coils. These difficulties were overcome by neutralizing the excess acid and by thoroughly insulating the steam coils from the rest of the machine and all parts of the machine from the ground. This is accomplished by means of non-conductor gaskets and bolts equipped with mica sleeves and washers.

Ammonium Phosphate

By WILLIAM C. WEBER

Chemical Engineer, The Dorr Co., Inc.
New York, N. Y.

• THERE ARE TWO ammonia salts of orthophosphoric acid which are of commercial significance, chiefly as fertilizers. The "mono" salt, $\text{NH}_4\text{H}_2\text{PO}_4$, has a pH of 4.4 and is extremely corrosive. Also, in its preparation from wet-process phosphoric acid, we must contend with the sulphuric and fluosilicic acids always present as impurities. In the United States, the monoammonium phosphate is preferred because of its relatively greater stability for mixing and complete fertilizers. The "di" salt, $(\text{NH}_4)_2\text{HPO}_4$, is of pH 8.0. It is of more balanced composition and is used extensively in Europe, but is somewhat unstable at slightly elevated temperatures or humidities. It is distinctly alkaline and not especially difficult to handle.

Methods of preparation vary somewhat. In the case of the mono salt, or "Ammophos," phosphoric acid, with or without the addition of extra sulphuric acid, is neutralized with anhydrous ammonia gas in mechanically agitated saturators. The resulting slurry may be dried directly in rotary direct fired dryers, pulverized and screened, or in the modification installed at Trail, B. C. (*Chem. & Met.*, Vol. 40, p. 72-5, 1933), the slurry may be blunged with previously produced and recirculated nodules and then dried, pulverized and screened, a sized product being sent to production and the fines returned to the blunger as seed.

In the case of the di salt, which is also the base of the various "Nitrophoskas," the phosphoric acid is customarily neutralized in two stages. In the first saturation to an $\text{NH}_3\text{-P}_2\text{O}_5$ mole ratio of 0.9 to 1.2:1, the bulk of

the impurities, Fe, Al, F, Ca, Mg, etc., is precipitated and removed by filter presses. The press cake is dried in a rotary drum or preferably on a twin drum dryer. The substantially pure monoammonium phosphate solution is evaporated, further saturated to a mole

Construction Materials for Ammonium Phosphate

Acid Feeders: (1a, 1b) Lead lined or rubber covered tanks and cast lead mechanism.

Ammonia Feeding: (1a, 1b, 1c, 2) Cast iron and stainless steel.

Saturators: (1a, 1b, 1c, 2) Lead and brick lined tanks, stainless steel mechanisms, stainless distributors.

Filter Presses: (1c, 2) Cast iron or wood.

Press Cake Dryer: (1c, 2) Cast iron drums, scrapers, etc. Cast iron and steel repulper.

Evaporator: (1c, 2) Cast lead or homogeneous lead lined body, stainless tubes.

Crystallizers: (2) Iron and steel.

Crystallizers: (1c) Stainless troughs and cast iron or stainless stirrers.

Centrifuges or Salt Filter: (2) Steel basket or drum, stainless screens.

Centrifuges or Salt Filter: (1c) Rubber covered or stainless.

Dryer for Centrifuged Salt: (1c, 2) Steel.

Blunger: (1b) Steel tank, steel and cast iron mechanism.

Rotary Dryer: (1a, 1b) Drum, lifters, fan, cyclones, etc., all iron and steel.

Screens, Pulverizers, etc.: (1a, 1b) Steel and iron.

Centrifugal Pumps: Cast lead and Illium, all stainless, or cast iron (for di solution).

Piping: Lead, rubber hose or iron.

Note—Only certain very special types of stainless steels are suitable.

ratio of 2:1, crystallized, centrifuged, and dried. This same type of flow-sheet with elimination of the second saturation has also been used for the production of a pure (except for ammonium sulphate) and crystallized monoammonium phosphate.

The processes described may be classified as follows:

1. Monoammonium phosphate
 - a. Saturation and direct drying.
 - b. Saturation and drying with fines circulation.
 - c. Saturation, filtration, evaporation, crystallization and drying.
2. Diammonium phosphate
 - Double saturation, filtration, evaporation, crystallization, and drying.

The accompanying tabulation gives best present practice in construction materials, the symbols following the equipment designation referring to the processes (as classified above) to which the unit is applicable.

Beet Sugar

EDITORIAL SUMMARY

• NO DIFFICULT corrosion problems are encountered in the beet sugar industry. On this account most of the equipment used is satisfactorily made of steel. Aside from the ordinary rusting of steel parts, about the only corrosive tendency that the industry must combat is that from the ammonia fumes that are released from the beet juices at various stages of the process. One reason for the smallness of the corrosion factor lies in the fact that the industry operates for only about three months out of the year. During the remainder of the year the operating crew, who are kept on the pay roll, are required to recondition the entire plant for the next campaign. In such a situation equipment which would normally corrode quite rapidly can be kept in good condition for many years.

Evaporators, in the past, have generally employed brass heating surfaces but there has been a recent tendency to resort to ordinary steel tubes in an effort to conquer ammonia corrosion.



FOR PROCESS INDUSTRIES

The final evaporation stage, in the "white pan" has often been carried out in cast iron and copper construction, but even this is not general for steel is used frequently in the handling of both the white mascuite and white sugar.

In filtration some factories use wire

cloth and for this purpose, Monel metal is most general, although stainless steel has also proven satisfactory. Between steel, copper and brass, therefore, with only occasional resort to the more expensive alloys, the industry has had no difficulty in conquering corrosion.

Bromine

By MAX Y. SEATON

Vice-President, California Chemical Co.
Newark, Calif.

• IN THE PRODUCTION and handling of bromine the use of non-metallic materials of construction is essential in most instances. Enamel-lined cast or wrought iron equipment has occasionally been employed. Lead is satisfactory when relatively cold, acid-free liquid bromine is encountered, but if much water is to pass through lead equipment, its life is seriously shortened. At best the deposits of lead bromide that soon coat all lead surfaces exposed to bromine may sooner or later become detached and give endless trouble through their collection in valves, bends or orifices. Only when the apparatus design makes impossible the use of ceramic equipment or glassware should lead be considered and then, if reasonable life is to be expected, conditions must be such that the bromine is fairly cold, neutral and dry.

But for its cost, tantalum would merit consideration as a general material of construction for bromine-producing equipment. It will withstand even such severe service as use for electric resistance heating coils immersed in boiling, wet, acid bromine. It can well be employed in the laboratory and for special small parts, but expense prohibits its use in large equipment.

A good grade of chemical stoneware gives excellent service in pipelines, valves, condenser coils, small towers, etc. Care should be taken, particularly when hot, wet, acid bromine or bromine vapors are encountered, to see that the stoneware is particularly well vitrified. Poorly burned Raschig rings, for example, will rapidly disintegrate when used in towers subjected to these conditions.

Low-expansion glassware (Pyrex) is particularly useful in the construction of pipelines and small columns. By use of Pyrex brand tubing of 3 and 4 in. diameter, condenser sections can be built up which show substantially higher rates of heat transfer than can be realized with chemical stoneware and which are simultaneously more resistant to thermal shock. If large ware is fabricated by local glassblowers, great care

to insure thorough annealing must be exercised, as otherwise mortality in service will be high. With glassware, as with stoneware, the dropped monkey-wrench is an ever-present hazard, and all reasonable protection against accidental breakage should be provided.

For large towers, operated reasonably cold, acidproof brick set in acidproof cement is usually employed. If towers must be operated at temperatures of 100 deg. C. or above, use of soapstone is probably more desirable. A close-grained granite is sometimes substituted for soapstone, but its greater thermal expansion is objectionable. Use of soapstone slabs, assembled with asbestos-silicate gaskets, permits a wide variety of tower and fractioning column designs to be fabricated.

Byproduct Coke

EDITORIAL SUMMARY

• BOTH ABRASION and corrosion are problems in the byproduct coke plant. The handling of the coke calls for materials that will resist abrasion and, in the vicinity of the quenching station, special materials must be used to prevent corrosion.

Among the principal applications of abrasion resisting materials are crushing equipment, screens, chutes, wharves and conveyors. For these purposes Stellite, hard cast iron, vitrified brick, rubber, tile, manganese steel and alloyed cast irons are used.

At a South Chicago plant ordinary steel coke pusher shoes wore down several inches in about four months. These were Stellite and at the end of three or four months the layer of hard surfacing material showed very little wear. Another advantage of the hard facing is the fact that the furnace floor did not show as much wear.

The coke wharf must withstand the constant sliding and rolling of hot coke over the surface. Vitrified brick, hard

cast iron, alloyed cast iron, rubber and tile have been employed to resist this severe service. Vitrified brick is used in many plants, replacing the cast iron plates which were formerly used for this application. In a few places rubber has been used and found to be satisfactory.

For crusher segments special manganese steel or special cast irons are used. An important property of a metal in this service is its ability to withstand shock. For this reason the best manganese steel is said to be the safest. To further improve the life of the crusher segments it has been found advisable to surface the tips with Stellite. Grizzly disks made of hard cast iron have been found to be satisfactory.

Several plants in the last few years have replaced cast iron standpipes with ones composed of a welded steel shell lined with a refractory material. This substitution has been found to reduce maintenance costs. More recently poured linings have been extended to the lining of oven doors.

One of the most troublesome problems in the byproduct coke plant is the corrosion of sheet metal used for covering conveyor galleries and buildings. Alloy or wrought iron sheets for this purpose have been found to be an improvement on the straight black or galvanized iron. Transite and other types of pressed or molded sheeting materials give better protection against corrosion but, of course, both first cost and weight will be higher.

Stainless steel is being used for pump shafts and sleeves, Monel metal for quenching pump impellers, lead lined steel for valves and piping and bronze and Stellite for valve seats and disks.

At the May, 1934, A.G.A. Production and Chemical Conference (*Chem. & Met.*, Vol. 41, p. 352, 1934) Chas. R. Locke of the Chicago By-Product Coke Co., presented the results of a questionnaire he had sent to 12 gas plants to determine any increase in applications of new materials for special service.

Calcium Chloride

By H. E. KREIDER

Chief Chemist, Columbia Chemical Division
Pittsburgh Plate Glass Co.
Barberton, Ohio

• DESPITE its long-held reputation as a corrosive material, calcium chloride does not present any serious corrosion problems in its manufacture. A good quality cast iron performs satisfactorily in most applications. Occasionally there are instances where graphitic corrosion gives trouble, as for example in pump parts. If the cause of the trouble can-

not be discovered and removed, bronze parts may be substituted, or other corrosion resistant materials used. Cast iron is generally recommended for the valves and cocks in a calcium chloride plant. Piping should be of wrought iron, preferably galvanized.

Calcium chloride evaporators usually are of cast iron with the tube and tube sheets of ordinary steel. Corrosion troubles may be prevented to a large degree by avoiding leakage of air into the system. Concentrating pans may be

made of sheet steel, but it is advisable to have the metal protected on the inside by chemically-resistant masonry set in acidproof cement.

Calcium chloride solutions may be shipped satisfactorily in tank cars. Steel drums are generally used for the solid or fused product. Flaked calcium chloride is shipped in steel drums, in waterproof, paper-lined burlap bags and in the new waterproof paper bags in which a sandwich of asphalt is enclosed between the paper laminations.

ommended. Pumps and valves used in a carbon tetrachloride plant require careful attention from the standpoint of materials used in their construction. Cast iron or stainless steel valves of the gate type are generally most serviceable in this process. Cast iron cocks have been used, but owing to the difficulty of lubrication they tend to bind and are, therefore, not as satisfactory. The pump commonly used is supplied with a cast iron casing and impeller and steel or cast iron shaft.

Carbon tetrachloride is shipped in bulk in steel tank cars. Lead-lined steel cars would make a much better container for bulk shipment since the necessity of scrubbing and scouring the tanks after each shipment would thereby be avoided. However, the only satisfactory method of construction involves a homogeneously lined lead tank which is, of course, considerably more expensive than a tank of bare steel. Drum shipments are made in galvanized drums and, owing to the difficulty in thoroughly removing scale and dirt, the trend is toward single-trip drums.

Cane Sugar Refining

By D. GUTLEBEN

*Pennsylvania Sugar Co.
Philadelphia, Pa.*

• SUGAR SOLUTIONS, if heavy, are not corrosive and are sterilized by a temperature of 185 degrees F. However, dilute solutions at favorable temperatures have a tendency to ferment. The heavy filtered liquors are stored in steel tanks but the piping and vacuum pans are usually of copper for the sake of cleanliness. A sugar coating inhibits rust but if it becomes washed off by steam, rust scales form to pollute the liquor. Dilute solutions (sweet water) will destroy a steel pipe in about eight years. If the pipe fails sooner it is replaced with copper or brass.

The older plants used cast iron for tanks but steel is considerably cheaper, especially since every refinery maintenance department is now equipped with electric welders with which repairs can easily be made. Some old cast iron tanks have been giving perfect service for over 30 years for all kinds of sugar liquors.

All piping and tanks for sweet water should be arranged for prompt draining

over the Sunday shut-down. During this period, the dilute solution cools, ferments and destroys its sugar content as well as the metal that contains it. The bottom part of a cast iron pump casing that is not properly drained over week ends will be eaten through in five years.

Floor grades should be steep for quick removal of spills. It is advantageous to arrange floor drain boxes respectively one above the other. The piping is then vertical except in the basement and there is no chance for it to plug and corrode.

Jet condensers of cast iron outlast steel at least two to one. When the casting becomes pitted, its life can be prolonged by covering it with red-lead putty protected by sheets of copper of about 20 B.w.g., bolted on.

Steel tanks for sweet water and for hot river water are usually made an eighth inch thicker than structurally necessary so as to allow for corrosion. Hot water for washing the finished sugar is stored in copper tanks and conducted through copper piping.

Cellulose Acetate

By H. C. WHITE

Bangor, Maine

• CELLULOSE ACETATE must not be contaminated in process by small quantities of impurities. This factor, together with cost, controls the use of materials of construction in the industry. Accordingly, aluminum is the best material for the storage of acid and anhydride, and to use for piping of all chemicals to the acetylator.

Copper lines are used to handle all exit materials, since they are less expensive and withstand the weak acid better than those of aluminum. Valves of a satisfactory material have been a problem to the industry. Leaks of a small size, which would not affect many other processes, are harmful in connection with this process. However, the development of valves and plug-cocks of compositions along the line of Allegheny metal has solved the problem quite well.

The use of vacuum and gravity flow

Carbon Tetrachloride

By WALKER PENFIELD

*Manager of Engineering
Pennsylvania Salt Manufacturing Co.
Philadelphia, Pa.*

• IN THE STANDARD process of producing carbon tetrachloride by chlorination of carbon bisulphide, cast iron equipment, owing to its low initial cost and its serviceability, has been extensively used. This is true particularly of the reaction and distilling equipment, up to the point where sulphur chloride is eliminated. Ordinary steel and wrought iron, although not particularly

serviceable in the presence of heat and sulphur chloride, are widely and satisfactorily used for storage tanks for crude and finished carbon tetrachloride. For the finished material, lead or tinned tanks would be preferable, but on account of their greater cost are not so generally used.

In the production of finished carbon tetrachloride, lead condensers are rec-



FOR PROCESS INDUSTRIES

is highly satisfactory in the transfer of liquids to the acetylator. Pumps constructed of some of the iron-chromium or iron-nickel-chromium alloys would quite likely stand up well. For handling weaker acids, pumps of phosphor bronze are used.

Copper, from the standpoint of

strength, resistance to corrosion and cost is the usual material from which acetylators are constructed. The 18 chrome-8 nickel steel, nickel and nickel-clad steel are also used for the construction of acetylators. For aging tanks, wood, stoneware and 18 chrome-8 nickel steel are being used.

Copper Sulphate

By **PIERCE BARKER**

*Metallurgical Engineer
Highland Park, Mich.*

• **BLUE VITRIOL**, as copper sulphate is commonly called in the trade, is produced in this country principally as a byproduct of electrolytic copper refining, although it is also produced by leaching metallic copper with dilute sulphuric acid. In a previous article (*Chem. & Met.*, May, 1932, p. 258-61) the writer has detailed the operations and equipment required for such a process. The following brief notes refer primarily to problems of corrosion and contamination which, of course, are affected by both the purity of the raw materials and the materials of construction used for the equipment.

The copper shot used must be reasonably low in iron and other elements that would contaminate the copper sulphate crystals. Fortunately, such elements as the precious metals form a non-contaminating slime in the settling tanks, but any other metal which could be removed only by fractional crystallization of the final product must be avoided for economic reasons.

The solution to be used for crystallizing must have its gravity built up with copper sulphate and not with sulphuric acid. If excess acid is used for this purpose, the resulting copper sulphate crystals will be porous and con-

tain cavities filled with the mother liquor which render them unfit for most commercial uses.

It is important that the crystallizing tank should be shaped so that the greatest amount of large crystals is produced since these are generally more desirable than the fines. Any means for increasing oxidation of the copper shot increases its solution in the sulphuric acid and favorably affects the economy of production. The fundamental reaction is the solution of copper oxide in sulphuric acid, and anything done to increase the rate of solution of the copper must be accomplished without contamination of the resulting solution of copper sulphate or increasing the rate of corrosion of the manufacturing equipment.

As noted in the article previously referred to and in the materials of construction compilation accompanying this issue, creosoted cypress wood, lead-lined wherever necessary, is probably the single most important requirement in copper sulphate manufacture. Acid-proof concrete is also effectively used. Wrought iron also has a very favorable record of experience in applications that do not involve severe corrosion problems.

• Chromates and Bichromates

By **J. J. VETTER**

*Chief Chemist, Natural Products Refining Co.
Jersey City, N. J.*

• **BOTH PRODUCER** and consumer of the several alkali chromates and bichromates are faced with corrosion problems that practically confine them to the use of iron and steel for equipment, a very agreeable if narrow limitation. Cast iron and steel are entirely unaffected, even after years of contact with these materials.

The nonferrous metals and alloys

are, in general, unsatisfactory, although copper-tin bronze containing a small amount of lead gives reasonable service for such parts as centrifugal pump impellers and gate valve seats. The occasional replacement of such parts hardly justifies their special construction in steel. Monel metal filter cloth can also be used, although steel would be preferred if it were available. Lead be-

comes coated with a film of lead chromate and, while it is satisfactory from a corrosion standpoint, there is a tendency for this film to rub or wash off and cause contamination. Sheet lead is sometimes used for joint gaskets.

Hot bichromate solutions are reduced when in contact with organic matter, hence wood, rubber or plastic molded materials must be avoided. Of the various gasket and packing materials graphited asbestos is the most suitable.

When bichromate is to be reduced with sugar and sulphuric acid, or sulphur dioxide, to produce basic chromium sulphate for tanning, the corrosion problem changes and iron is no longer suitable. Lead or wood are the materials generally used for this service.

In the dry state chromates and bichromates have no effect on wood and are stored and shipped in wood casks. Waterproofed paper-lined bags have also been successfully used, but danger of breakage has restricted their use.

Coal Tar Refining

By **J. M. WEISS**

*Consulting Chemical Engineer
New York, N. Y.*

• **IRON AND STEEL**, and occasionally lead, suffice to meet most of the corrosion problems in the coal tar refinery. For example, in the manufacture of naphthalene, iron and steel are suitable materials of construction except in the step of refining with sulphuric acid, in which case lead lining for agitators, pumps and piping, and Duriron for pumps, are the materials usually employed. There appears to be no corrosion problem in the use of naphthalene. In those cases where there is a problem, it is caused by some other material with which the naphthalene is mixed.

In subliming naphthalene the condenser houses are generally of wood or concrete inside, rarely fabric lined. There is no corrosion problem, but merely the necessity for keeping the sublimate clean.

It is true, of course, that certain alloys might give better results in some operations in the tar refinery, but in most cases these have not seemed worth the added cost.

In tar acid extraction iron and steel are used chiefly. For the refined acid tin worms and tin-lined receivers are employed, but this is more a matter of color than of corrosion. The extraction of pyridene involves the handling of sulphuric acid, necessitating the use of lead lined equipment. In the refining of solvents (benzols and naphthas) strong sulphuric acid is encountered and here cast iron is satisfactory.

MATERIALS OF CONSTRUCTION

Dry Batteries

EDITORIAL SUMMARY

• **THE MIXTURE** of solid material impregnated with moist electrolyte, which is used to make the active mass of a "dry" cell, is necessarily highly corrosive. When this material contacts with metal, one has the equivalent of many small short-circuited batteries, and both electrolytic and chemical corrosion inevitably follow when the contact is with almost any type of metal surface.

For much of the dry-battery plant, rubber lining of solution tanks, mixers and handling equipment has proven to be the correct answer, both economically and technically, to this corrosion problem. In the mixers wooden paddles are used. This means that until the mix is ready for forming, very simple chemical-engineering construction can defeat corrosion.

In the forming dies, however, rubber is unsuitable. For them a metal surface which will maintain dimensions to a thousandth of an inch during use is necessary. Here Stellite surfacing or Stellite parts have proven essential. Steel dies formerly used required almost daily replacement. Even "corrosion-resistant" alloy castings, though of much longer life, left much to be desired. But Stellite for such parts can often be used for weeks or even months within the dimensional tolerances maintained and, hence, amply justifies its greater initial cost.

In some parts of the solution-handling equipment rubber suffices, as in pipe, solution tanks and other unit devices. But in the precise measuring of solutions, particularly for feeding paste into the dry-cell cups in exact amounts, special alloy parts are required adequately to resist attack. Both Stellite and Monel maintain the important dimensions unchanged for considerable operating periods.

plicity in design and economy of material when expensive alloys must be used. Nitrated filter cloths have been used economically in acid concentrations up to 40 per cent and mohair and wool cloths with lesser concentrations.

Pumps are made in a greater variety of materials than any other type of equipment because they require little machining and can be made from materials obtainable only as castings; 18-8 and higher chrome-nickel steels, Hastelloy, Duriron, Durimet, Elcomet, Monel and aluminum bronze—to mention only a few—are all being used for pumping, with excellent results.

The foregoing has been based largely on Hugh Miller's much more complete summary of dye plant construction which appeared in *Chem. & Met.*, Oct., 1932, pp. 486-8.

Dyes

EDITORIAL SUMMARY

• **IN DYE PLANTS**, every type of chemical engineering equipment is utilized. Among the more widely used items may be mentioned sulphonators, nitrators, evaporators, autoclaves, filters of every description, reducers, dryers, crystallizers; and of course, pumps, vats and tanks. In this industry, as is doubtless true in others, there is no distinction in a name, the equipment being designated for what it does, rather than because it conforms to a conventional design. Thus, reduced to simpler terms, most of the apparatus would come under the heading of either tanks, vats, kettles, autoclaves, dryers, filters, and pumps; variously equipped to function in almost any capacity.

Sulphonation kettles are made of cast iron for use with oleum and strong sulphuric acid. Castings for this purpose containing up to 25 per cent Mayari iron (smelted from Cuban ore containing small amounts of nickel and chromium) have shown up unusually well. For weaker acids which attack iron, Everdur, Monel, Durimet, aluminum bronze and lead have been used with varying degrees of success, depending on temperatures and concentrations.

For fabrication of nitrators, where little or no sulphuric acid is present, 18-8 chrome-nickel steel gives the best results. When the nitration is carried

out in strong sulphuric acid, cast iron is generally used. Nitration masses containing smaller amounts of sulphuric acid have been handled successfully in high chromium steels such as Duraloy "A" or Ascoloy 55.

Very complete corrosion data are essential for autoclave design because of the pressures usually involved. 18-8 chrome-nickel steel is used extensively for caustic fusions under pressure. Bonded lead linings have proven satisfactory for such reactions as hydrolyses carried out with dilute sulphuric acid at elevated temperatures and pressures. Glass lined equipment when used under pressure has a distinct advantage, because there is no chance of the walls gradually thinning down to the danger point.

Because dye making is a batch proposition, wood plate-and-frame filter presses are widely used, both in alkaline and acid service. The product is not discolored by the wood and replacements are comparatively cheap. Bakelite plates and frames have also been used where their improved acid resistant properties justify the installation. Rotary filters can be made completely acid resistant by using rubber-lined steel, with Bakelite valves and fastenings. Nutsches can usually be fabricated at a cheaper initial cost than other types of filters and have the advantage of sim-

Dynamite

EDITORIAL SUMMARY

• **LEAD, BRONZE** and wood are construction materials that are much in evidence in a modern dynamite plant. Glycerine is nitrated in a steel nitrator, but the remaining operations in the lead-floored nitrating building are in lead-lined, wood and occasionally ceramic vessels. Rubber hose serves for the transportation to lead-lined storage tanks of the finished nitroglycerine. From storage the nitroglycerine is carried to the mixers in small copper tanks on wheels, known as buggies.

Ordinary dynamite is generally mixed in wooden mixers of the edgerunner type, while bronze Z-agitator mixers are often used for gelatine dynamite. Packing machinery makes use of wood so far as possible, and of bronze and other non-sparking metals. In the preparation of "dope" ingredients, however, there is little risk of explosion and construction materials are chosen for mechanical and corrosion requirements. For instance, ceramic linings are used in making ammonium nitrate, and steel for the various conveyors, screens and dryers. On the powder line buildings are largely of wood, but elsewhere protected steel, brick and concrete are employed.



FOR PROCESS INDUSTRIES

Electrical Manufacturing

By DAVID R. KELLOGG

Division Engineer, Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.

• IN OUR INDUSTRY the principal corrosion problems encountered are those involved with atmospheric corrosion, rather than of the more drastic sort, commonly faced by the manufacturer and user of chemical engineering equipment. Our protection against atmospheric corrosion ranges all the way from paint of the conventional type through lead, zinc and tin coatings, various platings, such as nickel and cadmium (the latter being particularly good), to a choice of corrosion resistant materials which are in themselves satisfactory without protection. Some of the newer aluminum alloys are of this sort, and we have also had some good success with silicon bronzes. Stainless steel is a standard material with us and, where its use is warranted, it has been highly successful. We also use nitriding, in some cases more for its protective value than for the increase in hardness, although it usually happens that the combination of hardness and protection is very desirable.

As a final note while on the subject of corrosion, may I add a personal observation, as the result of a good many years of experience in the use of a wide range of metals and materials? As I look back I sometimes feel that

a large portion of my time has been devoted to preaching, in season and out, on the utter criminality of placing different metals in contact when they will be frequently wet or immersed. It seems to me that in the last three or four years either this preaching or that of someone else has done some good, because quite often now, a design engineer will come to me and ask about some combination of metals before the job has actually been completed. Years ago I used to have the sad results presented to me with request for recommendation. Of course, everybody is supposed to know that there is some such thing as electrolytic solution tension, but I have been shocked and horrified at the suggestions that have been made by some design engineers, showing utter ignorance of all such matters on their part. When and if these men passed their final chemistry examinations in college, they must have said, "Thank God, that's done!" and then proceeded to forget all about it. As I said before, however, constant preaching does do some good and the number of horrible examples which get through to the finished product has, in the last few years been enormously reduced.

Ethyl Alcohol

By G. T. REICH

Pennsylvania Sugar Co.,
Philadelphia, Pa.

• FERMENTERS offer the first line of corrosive attack in an alcohol plant. The diluted molasses is treated with sulphuric acid which acts as a catalyzer to invert the sucrose, but remains intact in the solution to join with intrinsic organic acids in corroding the tanks. Fermenters of 100,000-gal. capacity, built of pure iron, have had the rivet heads eaten away in three years. These rivets had been specified to be of the same metal as the plates but they were not. The old rivets were then replaced, using a heat-controlled electric rivet heater. If the metal is not free from impurities, electrolytic action proceeds. Our recent practice has been to replace the rivets with welding, using a covered iron electrode. Rivets and joints thus resist acid attack more successfully.

Pure iron fermenters have now given ten years of service and, with skillful welding, their life should be extended at least five years. In the construction of fermenting tanks, good drainage must be provided and there should be no sharp corners. Lack of cleanliness courts destruction of the metal as well as of production efficiency. Recent large installations have been made of copper-bearing steel with butt joints welded and ground smooth. A polished surface better resists electrolytic action.

Some of our fermenters have been "metal-sprayed" with tin and some benefit was secured but the cost was not returned. This process requires sand-blasting and most careful workmanship. Recent improvements in metal spraying may now give better protection.

The ancient fermenters were made of wood; these have the objection of being difficult to keep clean and besides a large number of plants must now have tight covers for the collection of the CO_2 .

There are whiskey plants using copper fermenters built more than 50 years ago. This is comfortable for the maintenance department but it is uneconomical from the point of view of capital investment.

Scrubbers for CO_2 should be built of cast iron, although steel will serve for many years if kept well painted.

Stills, yeast machines, heaters and piping should be copper, as they receive the liquid from the fermenters. There may be alloys now on the market that will resist the corrosive action of fermented liquor more effectively than does copper, but experience with them has not been of sufficiently long duration to prove it. It is advantageous to increase the wall thickness beyond the bare structural requirements.

Evaporators and other processing equipment for the waste from the stills should be copper.

Bronze pumps have served effectively for fermented liquor. After eight years of service some of these were worn or corroded and the wasted surfaces were built up with a bronze electrode.

Steel pipe sewers for the hot waste from the stills last about one year. Pipes of 14 B.w.g. copper have served eight years and have been replaced with 10 B.w.g. copper. Vitreous pipe with joints made with Hoechst cement gives promise of long life. Cast iron pipe, underground, has been eaten away in ten years. If sulphuric acid leaks from a sewer it may char the piles under a foundation and thus do serious damage.

Large alcohol storage tanks are made of steel. Specially denatured alcohol requires copper or enameled steel, according to the quality of the denaturant. Pure alcohol does not rust steel, but rust may form on uncovered plates. Alcohol intended for beverage purposes can be shipped in steel containers. The demand for wood barrels is psychological rather than chemical.

Electrolytic Caustic

By L. D. VORCE

Westvaco Chlorine Products, Inc.
New York, N. Y.

• CORROSION PROBLEMS are probably more important in the electrolytic caustic process than in the lime-soda process. The brine is ordinarily handled in iron, but the possibility of stray currents finding their way into the feed line to the cells makes it desirable to

MATERIALS OF CONSTRUCTION

break the line as it enters the cell with a special non-conducting feeder which delivers the brine in slugs. The cells themselves are made in a number of different constructions, for the cell container the most common materials being concrete or steel, or combinations of these, or slate, or cast iron lined with acidproof brick. The anode material is invariably of graphite and the cathodes of steel or iron—or mercury in the case of several well known cells. Diaphragms are of asbestos paper in most cases.

Stoneware lines are used to withdraw the chlorine from the cells, and stoneware towers for the drying of the gas. Liquefying equipment for the chlorine is of steel and cast iron, as required.

In the early days of electrolytic caustic production when 74 per cent caustic was the standard commercial article, copper evaporator tubes were satisfactory, but with the advent of 76 per cent caustic, the additional concentration in the evaporator made copper unsuitable. Nickel is now used for tubes and tube sheets, and nickel cast iron for evaporator bodies. Pumps for evaporated liquor commonly employ nickel cast iron liners and Monel metal impellers. Liquor preheaters are supplied with nickel tubes. Cast iron lines have to some extent replaced steel, while nickel cast iron is used for fusion pots.

Glycerine

By OSCAR H. WURSTER

*Wurster & Sanger, Inc.
Chicago, Ill.*

• GLYCERINE has no appreciable corrosive action on steel and this metal is therefore suitable for most of the equipment used in its processing from the dilute, spent, soap lyes and autoclave or Twitchell sweet-waters to the refined grades. A number of conditions, however, exist in the various steps of the processes which make more resistant materials of construction desirable or necessary.

In treating the dilute liquors for purification before concentrating to crude glycerine, hydrochloric or sulphuric acid are used. Tanks for these treatments are usually cypress or lead lined steel. For the storage of hydrochloric acid, rubber lined tanks are used. Cast iron is well suited for the presses for filtering the neutralized liquors.

Spent soap lyes contain considerable salt and the evaporators for concentrating to crude glycerine are constructed of cast iron with copper tubes and tube sheets for the calandria. Steel plate evaporators with steel tubes may be

• VERY LITTLE of the equipment used in flat glass manufacture is standard. Most of it is specially designed and built to meet the problems of the individual glass maker. Except in the glass tank and in certain of the finishing operations, materials are chosen for their mechanical properties or for heat or abrasion resistance.

Molten glass exerts a very severe corrosive action on the side walls of the glass tank. For this reason special refractories known as flux blocks are required. Cast refractories for this purpose are a comparatively recent development. Silica brick, laid up dry without bonding material, are used for the crown of the tank.

From the tank the glass is withdrawn as a sheet through large cast iron rolls, passing then over asbestos rolls through the lehr where it is cooled to room temperature. After the lehr the glass is conveyed to the laying yard where plates are laid on heavy cast iron decks on which they travel to the grinders and

Glass

By R. A. MILLER

*Pittsburgh Plate Glass Co.
Pittsburgh, Pa.*

polishers. In the former operation the abrasive, consisting of carefully graded sand in water, is applied by cast iron blocks which are attached to large cast iron disks.

This coarse grinding is followed by a "smoothing" operation using emery, silicon carbide or similar abrasive. The polishing is accomplished with rouge in water containing ferrous sulphate and the mixture is applied on special felt pads carried on cast iron spiders. Following the polishing the glass is transferred to the wash house where it is thoroughly scrubbed with a dilute solution of hydrochloric acid. It is then examined and carried to the warehouse where it is cut into standard sizes for shipment.

Abrasive materials are commonly handled in rubber-lined conduits, although we generally employ cast iron pumps. Wherever necessary we use rubber-lined valves. Rubber-lined equipment is also used for the handling of hydrochloric acid.

While glycerine is not contaminated by clean steel or cast iron surfaces of the equipment, it is necessary to guard against rust in the finished product, both on account of the iron content and the discoloration resulting therefrom. Glycerine does not dissolve steel or cast iron but it does dissolve iron oxides. Equipment standing idle between runs may accumulate moisture on the surfaces, resulting in rust spots. Glycerine is hygroscopic and wetted surfaces may become rusty. Refined glycerine may therefore accumulate some rust and become discolored in steel processing tanks, cast iron filter presses and steel storage tanks. Such equipment has, therefore, in some cases, been coated with zinc or tin with good results. Stainless clad steel has also been used for decolorizing and storage tanks for chemically pure glycerine.



FOR PROCESS INDUSTRIES

Hydrochloric Acid

By **GEORGE M. GRAHAM**

*Merrimac Chemical Co.
Boston, Mass.*

• **FAME AND FORTUNE** await the man who finds an inexpensive material which will withstand hydrochloric acid in all phases and variations of temperature and moisture. Until that time suitable materials must be chosen specifically.

The finished product, a fairly pure solution of not more than 40 per cent strength, presents relatively small difficulty. Several manufacturers now line steel tanks for storage and shipping with vulcanized soft rubber, strongly bonded to the metal. Piping for cool acid is usually of hard rubber with screwed fittings. Properly supported, this will last many years, although a long line may present a different appearance in July and January. Rubber lined steel has greater strength and lower thermal expansion but does not lend itself to quick repairs and changes, since it must be ordered from the factory in definite lengths. It is useful for conveying warm acid.

Plug cocks of hard rubber, while far from perfect, seem the most practical valve, although rubber lined valves of the diaphragm type have shown encouraging results. Reciprocating pumps of hard rubber are fairly satisfactory but centrifugal pumps of Durichlor possess some advantages.

Glass and ceramics, while fragile, have never been displaced entirely by newer materials, particularly where hot acid is involved as in cooling coils, etc. Recent tests indicate a possible use for Haveg in this connection, as well as for vessels for reactions where hot hydrochloric acid is used. Such vessels may also be made of steel, lined with asphalt treated asbestos and then with two layers of acidproof tile.

Cool hydrochloric acid in the gaseous phase is inexpensively and conveniently conveyed in stoneware pipe, packing the bell and spigot joints with soft luting. Rubber lined steel also finds its place, as in exhausters, which show long life except for occasional recovering of the impellers. In this application Hastelloy or Durichlor should be even more satisfactory. Absorption towers are made of drainpipe set in granite saucers, but the greater cost of pitch-soaked sandstone is probably justified by longer life.

With increased temperature, difficulties arise. Up to 80 deg. C. hard rubber bonded to steel by means of a soft rubber layer is very useful. Tests indicate that Haveg can also be used at these temperatures and even higher, al-

though there is a tendency to warp above 200 deg. C. and in the presence of small amounts of sulphuric acid. Durichlor also is useful under these conditions but the tile lined steel mentioned above is satisfactory and much cheaper. Aside from its extreme fragility, silica ware is favorably re-

garded by some acid manufacturers.

In the presence of sulphuric acid and above the dew point, but not over about 450 deg. C., cast iron is reasonably satisfactory, although certain iron-chromium alloys are better, both as to corrosion and abrasion. Duriron and similar alloys are also serviceable. Where metal is not required for strength, or where the temperature is above 450 deg. C., firebrick, acidproof brick or shapes of various ceramics with fine clay or acidproof cement joints may be used. Alundum and carborundum tile are applicable and valuable because of good heat conductivity.

Iodine

By **P. F. HOLSTEIN**

*Chemical Engineer
Los Angeles, Calif.*

• **INTERMITTENT OPERATION** of iodine manufacture in Chile (normally a plant may operate six months to produce its quota and then remain idle three years), the cheap cost of production and high profit per unit, and the relatively low cost of construction of an iodine plant have all militated against the use of expensive corrosion-resistant apparatus. The greatest item of cost in the operation is the reagents used. Even with a high replacement and maintenance charge, these items, as also amortization charges, per unit of production cost are relatively of minor importance. The situation will be made clear from the fact that at the old price of iodine (when present plants were constructed) an iodine plant costing \$25,000 could produce in a year \$1,000,000 worth of iodine. Even at today's price of iodine the value of the production would be \$250,000. In the United States the industry, still in an experimental and development stage with the future insecure, has necessarily avoided expensive capital outlay. Makeshift equipment has rather been the rule.

In the iodine industry, both in Chile and in the United States, large volumes of liquids containing iodine or iodine salts are handled. Corrosion of pipe lines and pumps is avoided by arranging the operation so that only liquids containing the iodine in the form of non-corrosive iodine salts are pumped, in so far as possible, or handled through pipe lines. Precipitating tanks where free iodine is liberated are, in Chilean practice, of steel painted on the inside with tar, or of wood; in American practice, of wood or concrete. Any steel or iron directly in contact with free iodine will, of course, corrode rapidly. For

liquors containing iodine sludge or free iodine in solution, Duriron can be used to advantage in pumps and fittings, although a logical layout of plant will avoid the pumping of such material. Retorts in Chilean practice are of cast iron lined with cement. In American practice, with steam distillation, metal has been used with unsatisfactory results; stoneware should be satisfactory. Where the fusion method of purifying the crude iodine has been employed in American practice, porcelain bowls or enamel-lined apparatus have been used. Condensers, both in Chilean and American practice, are stoneware sewer pipe sections. Troughs, canals and filter boxes in contact with liquor containing free iodine are of wood. Iodine is packed and shipped in hard wood kegs.

Linseed Oil

By **DAVID R. KELLOGG**

Division Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

• **LINSEED OIL** is not generally regarded as a corrosive material, and yet there are many applications for special alloys and corrosion resistant metals, both in its manufacture and use. In the varnish industry, for example, both Monel metal and copper are widely used in preference to iron, since the color of the finished product is never quite as good when made in iron equipment. Of course, the actual attack of the hot linseed oil on the equipment is not, even in the case of iron kettles, a particularly

MATERIALS OF CONSTRUCTION

serious matter, but anything which increases the color of a clear varnish is definitely harmful to its salability.

Electrical manufacturers have another sort of trouble in connection with linseed oil varnishes; namely, corrosion of copper or brass parts when coils impregnated with varnish are enclosed in tight cases with such non-ferrous metals. We have also had the same type of corrosion resulting from the use of varnish-treated "spaghetti" in control equipment. This is not a very common source of trouble, as most such equipment has sufficient ventilation so that the natural breathing removes the organic acid which results from the oxidation of the linseed oil in the varnish.

It has occasioned, however, some difficulty in connection with special types of tight relays. We have overcome this to a very large extent by more thorough baking of the coils and by substitution of Cellophane or cellulose acetate insulation for the varnish cloth spaghetti. In some instances even this has not been entirely satisfactory, and it has been necessary to use materials which would not be attacked by these acids. In general, our experience has been that the vapor phase is the place where most trouble of this kind occurs. We have even noted instances where corrosion in the vapor phase may result from the long continued oxidation of insulating oils.

Lithopone

By JOHN P. HUBBELL

*Singmaster & Breyer
New York, N. Y.*

• IN MAKING LITHOPONE, zinc raw materials are dissolved in moderately dilute sulphuric acid, and barytes is reduced at red heat with carbon to form a soluble barium sulphide. The two solutions after purification are mixed and the lithopone precipitate is filtered, dried, calcined, quenched, wet ground, redried and disintegrated.

The equipment used to make the zinc solution must withstand the action of moderately dilute sulphuric acid in the presence of an abrasive solid. If the zinc material itself is a relatively non-abrasive material, for instance refuse zinc oxide, byproduct smelter or brass foundry fume, wooden equipment with lead pipes and pumps is satisfactory. Where zinc or other abrasive material is used, the wooden tanks are lead-lined and the lining protected with an inner lining of brick. In this case the stirrers should be made of Duriron, Alcumite or other acid resistant and abrasion resistant material. Rubber linings and rubber covered stirrers are satisfactory if not too expensive.

Once the zinc has been put in solution and the zinc sulphate has been brought to the neutral point, purification of the solution is carried out in wooden tanks and wood or iron filter presses with lead, brass or even iron pipes and iron pumps.

Ordinary firebrick is used in the rotary steel barium reduction furnaces which are either continuous or, if of the hatch type, fired with pulverized coal. The barium sulphide solution in the concentrations encountered in lithopone manufacture is non-corrosive to iron and steel. Leaching and liquor

storage plant can, therefore, be of steel.

The precipitating tanks are wood and from this point on the wet product should be kept away from metal as much as possible, since even slight contamination with metallic compounds will seriously affect light resistance and the extreme white color which is one measure of the highest grade lithopone. The rate of corrosion in an iron pipe or pump through which the slurry is passing continuously is not sufficient to cause any difficulty, but all equipment which comes in contact intermittently with the slurry or the wet filter cake should be made of wood or a metal to prevent contamination of the product.

The crude slurry is somewhat more corrosive than the calcined slurry from the wet grinding and for this reason much of the crude lithopone is still dried in tunnel dryers, using wooden trays, or in some cases heavily galvanized iron or aluminum trays.

Lithopone is muffled in a non-oxidizing atmosphere at a temperature of about 700 deg. C. Muffles of the vertical tube type can be made of steel piping. Horizontal rotary muffles internally fired, if large, are constructed of steel with refractory linings. Smaller muffles are also used where the tube is made of Nichrome, Hybnickel, or other heat resistant alloys.

Continuous screen belt filter dryers are quite generally used for the finished filter cake. The screen on the finished dryers is made of a stainless steel.

The dried product must be carefully protected from all forms of contamination, which makes it desirable to handle it in wooden bins and galvanized chutes.

Methanol

EDITORIAL SUMMARY

• WITH THE EXCEPTION of equipment coming in contact with carbon monoxide-hydrogen mixtures at certain critical temperatures, the choice of materials of construction for methanol synthesis is largely determined by mechanical rather than by corrosion requirements. The gas mixture is corrosive only under the conditions met in the heat exchangers and converter and the materials used in these cases are not well standardized. Tubes of bronze, other copper alloys and stainless steels such as 18-8 and 17 chrome have all been used satisfactorily for contact with the gas. Tubes with a copper liner or copper-plated have been suggested as possibly suitable. Chrome-nickel and chrome-vanadium steels have been used for converter parts not in direct contact with the hot gas mixture.

Compressors are of standard construction, employing cast iron, cast steel and forged steel as required. Copper is the material chosen for the distilling equipment.

In the wood alcohol industry copper, bronze and brass are the materials used universally for most of the equipment. Pipes are sometimes of steel or cast iron and shipping containers always of steel, but these represent the only departures from the copper-copper alloy rule.

Nitrate of Soda

By P. F. HOLSTEIN

*Chemical Engineer
Los Angeles, Calif.*

• IN MANUFACTURE of Chilean nitrate of soda by the Shanks process, boiling tanks, crystallizing pans, piping and canals are all of steel construction, with pumps of steel or cast iron. Ordinary brass valves are quite commonly used, but as there is gradual corrosion of the brass parts usual practice is to use cast iron plug valves wherever possible. On evaporators, where higher temperatures are reached than in the



FOR PROCESS INDUSTRIES

leaching operation, brass corrodes rapidly so cast iron plug valves are most satisfactory. Very few evaporators have been used in the industry, those installed being of steel shell with charcoal iron tubes. Burt filters, installed in several plants, labored under a corrosion and wear difficulty with the filtering medium which was satisfactorily solved by the use of Monel metal filtering mesh. Corrosion in isolated cases has occurred due to the magnesium chloride content of the liquors or the liberation of iodine, or solely to faulty operation, as for example, the baking of the leached mass on to the steam coils. Correction of the operation will eliminate the corrosion in every case. The Guggenheim process uses very large concrete leaching tanks, but no problem of metal corrosion dictated this construction.

Nitric Acid

EDITORIAL SUMMARY

• WHEN ASKED to prepare this summary of materials of construction used in the manufacture and handling of nitric acid the chief engineer for the largest producer insisted that the story could all be told in two words: "chrome iron." He added, further, that there has been no significant change in this situation since it was covered in greater detail, first by Bellinger of the Hercules Powder Co. in *Chem. & Met.*, November, 1930, p. 691-2, and subsequently by Thomas McKnight of the same company in *Chem. & Met.*, September, 1932, p. 490-2.

Turning to these articles, one finds ample reason for the popular acceptance of chrome iron in the nitric acid industry. Bellinger, for example, states: "Chrome iron has many uses in ammonia oxidation plants producing 55 to 65 per cent nitric acid. From the standpoint of efficiency and economy, it cannot be substituted by other alloys. It is used alike for castings, piping, tanks and absorption towers."

McKnight sounded a note of warning, however, by pointing out that the high quality standards set by the first chrome iron were not always being lived up to by some of the present-day products. He emphasized the fact that these earlier chrome-irons showed corrosion rates as low as 0.017 in. penetration per year, with a maximum of 0.076 in., while in 1932 he found samples giving as high as 1.0 in. penetration in a period of a year.

Asked if any recent difficulties had been observed with chrome iron, the

chief engineer replied that the only case he knew of was in connection with some of the tubing. One rather serious failure was traced to a defect on the inner surface of the tube which could only have been detected by X-ray examination.

He, too, emphasized the statement of McKnight that quality is an extremely important consideration to which the producers must give increasing attention when their construction materials are used for nitric acid service.

Nitrocellulose

By E. F. THOENGES

*Assistant Superintendent, Hercules Powder Co.
Parlin, N. J.*

• IN THE NITRATING area, the use of chrome-nickel steels has become more and more general in recent years. Nitrating pots are now being made of rolled 18-8 chrome-nickel steel throughout. The use of various chrome steels in centrifugal wringers has been given considerable study by all the leading nitrocellulose manufacturers. Those parts of the centrifugal in which corrosion resistance is of chief importance are now generally made of some chrome-nickel alloy; in those portions of the centrifugal in which safety is the governing characteristic, the introduction of chrome-nickel alloys is still in the development stage.

For fume lines to carry off acid vapors and for flume lines to carry off acid water, salt-glaze terra cotta has been standard for decades. At points where special line shapes are needed, thin chrome iron sheet is used. Mixed-acid tank vents have proved most satisfactory when made of aluminum.

The treating tubs used for the purification of nitrocotton have been made of cypress for many years. The durability

of this wood for this service is such that it has never been found practicable to replace it. To prevent contamination of the nitrocotton, the tubs are usually lined with a thin sheet of a chrome alloy of the straight 18 per cent chrome type. Tub castings are extremely satisfactory when made of a chrome alloy of the straight 26 per cent chrome type. For the tubing of the Milliken digester, in which the viscosity of the nitrocellulose is continuously reduced under conditions of elevated temperature and pressure and mild acidity, chrome alloy tubes of the straight 18 per cent chrome type are proving to be the proper material.

Buildings in this industry generally have a steel frame work with a brick sheathing. Roofs of short leaf yellow pine and felt roofing paper have proved to be the most practical and economical type. The most recent advance in material for construction in the industry has been the protection of steelwork generally with Tornosit paints. Tornosit is a chlorinated rubber compound. When properly formulated, it has proved to be the best coating for acid conditions.

Phenol Formaldehyde Plastics

By A. J. WEITH and J. H. SCHMIDT

Bakelite Corp., Bloomfield, N. J.

• SINCE BOTH phenol and formaldehyde are extremely reactive chemicals, the problem of corrosion in the plastics industry is an ever present one. Judging from a recent article ("Corrosion of Metals by Phenols," Rhodes, Riedel, and Hendricks, *Ind. & Eng. Chem.*, Vol. 26, p. 533, 1934), none of the more common metals is entirely resistant to the corrosive action of phenol. Cresols and the high boiling tar acids are even more reactive. A particular factor to be considered is the presence of moisture. Aluminum, for example, while fairly resistant to the wet vapors of tar acids, is completely disintegrated if the vapors are dry, whereas the reverse ap-

pears to be true in the case of a high carbon steel.

Formaldehyde is peculiar in some ways. While under some conditions it acts as an inhibitor and retards the corrosive action of acids on metals, work in our own laboratories has shown that it attacks practically all metals to a greater or less extent, the degree of corrosion increasing with temperature.

Added to this problem of corrosion is the necessity of choosing that metal which can best be fabricated to withstand the strains and stresses incident to the manufacture of resins. Agitators in the reaction stills must be strong enough to stir vigorously the very fluid

MATERIALS OF CONSTRUCTION

reactants at the beginning and the very viscous resinous mass at the end of the reaction. The reaction is an exothermic one, with the result that at a certain stage there is a sudden increase in temperature and also of pressure if operating in a closed system. Release valves must be specially designed. High temperatures are at times required, which means in most cases high pressure steam. Rapid heating and cooling are very often necessary. The high stresses thus induced may carry structural materials beyond their elastic limits unless designers and manufacturers pay particular attention to the choice and correct fabrication of the metal they employ. Not every corrosion resistant metal lends itself to the design of stills which will withstand these severe conditions.

Ordinary cleaning is a problem. In

many cases alkaline solutions are used for this purpose and consequently some metals which would resist the corrosive action of the reactants cannot be utilized because of the difficulties cleaning would entail. There are also times when the reaction gets out of control, in which case someone has the unpleasant duty of chiseling out the gelled resin. Few indeed are the corrosion resistant metals which do not suffer under this treatment.

The problem of the plastics industry is, therefore, not alone to choose a metal with the requisite corrosion resistance, but also one which possesses the necessary mechanical strength to permit the design of reaction vessels capable of withstanding those extreme conditions which are part and parcel of resin manufacture.

Phosphoric Acid

EDITORIAL SUMMARY

• IN THE PRODUCTION of phosphoric acid by the so-called wet process, involving the reaction of phosphate rock and sulphuric acid, some exceedingly difficult materials problems are encountered, by reason of the abrasive character of the rock and the presence of hydrofluosilicic acid. William C. Weber (*Chem. & Met.*, Vol. 39, pp. 542-45, 1932) in the most recent and most complete exposition of this industry's materials difficulties has stated that wood, lead, rubber, chemical stoneware, high silica brick and cement, and a special heat-treated, low-carbon, chrome-nickel-molybdenum steel, properly used, are the materials that have worked out most satisfactorily.

In the wet grinding process, using weak phosphoric acid as the grinding solution, the most satisfactory lining for the steel shells of the mills is rubber bonded to the metal, inside which is a shock-absorbing layer of wood strips and within this a lining of silica blocks set in acid resisting cement. Danish flint pebbles are used as the grinding medium. The manhole frame saddle and cover are of special stainless steel.

Wood is satisfactory for agitator parts in weak acid of say, 10 per cent P_2O_5 , and usable, though quite short lived at concentrations as high as 22 per cent P_2O_5 and temperatures as high as 70 deg. C. The agitator tanks may be of steel, wood or concrete. Steel or wood should be lead lined and the lead protected from abrasion and fluorine attack by a lining of acid resisting brick. Concrete should be lined with a double layer of acid resisting brick set in acid resist-

ing cement. Wood impregnated with paraffin is suitable for the tank cover and for fume ducts. Wood construction, with the metal parts of special stainless steel, has been satisfactory for weak acid agitator mechanisms. The agitator blades are of hard lead with an abrasion resisting facing of alundum grains. For strong acid, the agitator parts are preferably of rubber and special stainless.

Thickener tanks of wood should be lead lined and supplied with wooden covers. Concrete tanks, however, are best lined with acid resisting brick. Rake mechanisms of wood with stainless steel bolts are suitable, although the blades should be of alundum-protected hard lead. For stronger acids, rubber covered steel works well.

In filtering weak acid, the filter drum may be made of wood. For stronger acid, cast lead is good but rubber covered steel is the best construction. The filter valve, according to the most approved construction, employs a special stainless steel seat and antimonial lead valve cover. All metal parts that must be exposed are of special stainless steel and the cloths most satisfactory for very strong acids, nitrated cotton or silk.

Lead and brick lined wooden launders are used in preference to piping when possible. Lead pipe would be satisfactory were it not for the fact that some of the solutions deposit crystalline scale, making it desirable to use rubber acid hose in many cases. For the sludges, hard lead diaphragm pumps for weak acid, and rubber lined centrifugals with stainless impellers for strong acid, are employed satisfactorily. Solution pumps may be of hard lead for weak acid, or special stainless steel for strong acid.

For the concentration of phosphoric acid, single-effect vacuum evaporators or drum-type concentrators have been used. The body of the evaporator is of cast lead or brick lined. Tube sheets can be of hard lead and the tubes of lead covered copper.

Petroleum Refining

By GEORGE B. MURPHY

Manager, Research and Development Laboratories
Universal Oil Products Co.
Riverside, Ill.

• WITHIN RECENT YEARS considerable advance has been made by the petroleum industry in the selection of materials of construction for resistance to corrosion, high temperature and high pressure. Improvements were especially needed in the case of the materials used for tubes in the cracking processes where pressures of the order of 1,000 lb. per sq.in. and temperatures in excess of 1,000 deg. F., together with charging stocks containing high percentages of sulphur compounds, were being encountered. New treating processes employing corrosive reagents and gas polymerization plants are recent developments which require unusually careful selection of construction materials.

[In the construction of crude distilling and cracking equipment, both corrosion resistance and strength are required. The principal corrosive agents encountered are hydrogen sulphide and, to a lesser extent, hydrochloric acid generated by hydrolysis of soluble salts.] In



FOR PROCESS INDUSTRIES

the case of furnace tubes there is the additional problem of oxidation and attack by furnace gases on the heated side. With the increased temperatures of modern cracking processes, materials are required which possess good tensile and "creep" strength at high temperature and freedom from all internal structural and chemical changes, as well as resistance to external attack. Where corrosion and temperature conditions are relatively mild, plain 0.1-0.2 per cent carbon steel may be used. However, longer life, particularly under severe conditions, is obtained with alloy tubes of 4-6 per cent chromium and 0.5 per cent molybdenum. This alloy, more or less made popular by the petroleum refining industry, has a high creep strength, a stable structure and good resistance to oxidation and corrosion. By calorizing the tubes, these latter properties are further improved.

For very high temperature service in furnace construction, such as for tube supports and baffles, high chromium alloys containing 27 to 29 per cent chromium and 10 to 12 per cent nickel are satisfactory. Under milder conditions a good grade of cast iron may be used.

Reaction chambers, fractionating towers, evaporators, and similar vessels are ordinarily constructed of low-carbon steel and are provided with liners where corrosion is severe. Excellent service may be obtained with a welded liner of high-chromium alloy steel. Recently considerable success has resulted from the use of sprayed aluminum liners. This method is tending to supplant the older practice of reinforced ganister or sodium silicate bonded liners.

Sulphuric acid treating is still carried out in steel and cast iron equipment with lead lining provided where water washing results in dilute acidic liquors. Application is being found for some special alloys of the nickel-iron-molybdenum type in pump parts, mixers, etc. As pointed out by Morrell and Bergman (*Chem. & Met.*, April, 1928, pp. 210-3) pumps handling light distillates are usually of cast iron with rods of Monel metal or acid resisting bronze.

No particular corrosion or material problems arise in plumbite sweetening or in any of the clay processes for treating gasoline or other stocks. Ordinary carbon steel and cast iron are used.

In the newer gasoline treating processes, particularly the Lachman and the Day, numerous corrosion problems are encountered requiring special materials. In the former process, using an aqueous solution of zinc chloride, a ceramic-lined steel tower with copper trays and bronze valves and fittings serves as the contactor. In the Day process where HCl is employed a ceramic-lined steel tower is used. The hydrochloric acid is stored

in rubber-lined tanks and handled in rubber-lined pipe with valves and pumps of Hastelloy A, an alloy of nickel, iron, molybdenum and manganese. The tube for injecting the acid into the hot-treating tower is tantalum-lined steel. The fractionating tower following the treater is of ordinary steel as it has been found that the vaporized hydrochloric acid here is not corrosive.

pulverizer plows and plow arms to be economical. This hard surfacing is also used on roll crushers for crushing rock preparatory to pulverizing and on screw conveyor flights, etc.

Kiln liners are generally constructed of high-alumina refractories to resist the very high temperatures. Pyrosteel is used for feed pipes and burner pipes for the same reason.

Portland Cement

EDITORIAL SUMMARY

• PORTLAND CEMENT manufacture is faced with the problem of handling materials that are unusually abrasive. The most severe wear is in the crushing and conveying equipment. For these purposes Stellite and Hascrome surfacing, manganese steel and chilled steel are in use.

A plant in New York has standardized on Stellite grinder rings not only because of their long life but also because of the more efficient service rendered. The efficiency of this type of hard-surfaced ring is not impaired until all of the special alloy is worn off. Moreover, the cement particle size remains constant whereas with the plain steel ring it increases.

For hammer mills chilled steel is used in breaker plates in some plants. At least one mill is using Hascrome as a hard-facing on the large hammers of the swing pulverizers. The special surface does wear away but it can be renewed many times. Liner plates of tube mills are made of manganese steel because of its resistance to abrasion and ability to take and keep a polish.

In the pulverizing of the cement clinker after it has been cooled, some plants have found the Stellite surface on

Potash

EDITORIAL SUMMARY

• IN THE TRONA PROCESS of potash recovery most of the materials requirements are successfully met with cast iron and steel, with occasional use of non-metallic materials, stainless steel and copper alloys.

Underground piping is either of cast iron or of wood or stone. Steel or cast iron serves for overhead piping, and cast iron or terra cotta for sewer lines. Both charcoal iron and seamless steel tubing are used for heat exchanger tubes, together with some Admiralty metal. For the evaporators, steel or cast iron bodies and heaters have proven satisfactory.

Cast iron centrifugal pumps with steel shafts are generally employed, although a few pumps with stainless and other alloy steel impellers have been tried. Both bronze and steel have been used for centrifugal baskets and cast iron for filters, with Monel metal cloths. Unlined steel plate construction is used successfully for the rotary dryers.

Similarly, cast iron and steel are the materials used at nearly all points in the production of potash from sylvinites. Steel is used for the storage bins, piping and coolers and cast iron for the digesters and evaporative crystallizers.

Printing Ink

By W. F. HARRISON

San Francisco, Calif.

• PROCESSES involved in the manufacture of printing ink from pigments and vehicles require no extraordinary construction materials. As with paint materials there is no corrosion involved. Grinding mills, which are usually of the three-roll type, are made of case hardened steel. The vessels for mixing, handling and storage may be made of any convenient and sufficiently sturdy material, usually ordinary sheet iron.

In years past the processing of print-

ing ink vehicles was carried on in copper varnish kettles and is often so handled at present, but chrome-nickel steels and Monel metal are rapidly replacing copper for this purpose because of longer life over the direct flame and improved resistance toward the organic acids contained in vegetable oils and resins. This reactivity between organic acids and metal is not sufficient to make it a problem of corrosion; it is simply one of color. Far lighter colored ink

MATERIALS OF CONSTRUCTION

vehicles are obtainable from Monel metal or stainless steel kettles.

A review of construction materials for process equipment in the printing ink industry would hardly be complete without mention of a few of the corrosion problems in dry color making. Chemical dry colors are probably universally precipitated in wooden tanks although it cannot be said that wood is entirely ideal. Its life is long but the action of the chemicals involved causes a continuous slivering off of wood fibers that sometimes is very troublesome to the ink maker. The soft woods like redwood are especially bad in this regard and harder woods are not entirely free from the fault.

Because colors are often well washed in the striking tanks, the corrosion in draw-off pipes and pumps is not as severe as in the siphon and entering steam pipes. Acid resisting brass has fairly long life in the draw-off pipes and in the making of some colors is satisfactory for pipes and fittings within the tank. The making of ferrocyanide blues pro-

vides the most several corrosion troubles of all the chemical colors.

Pipes within these striking tanks will serve for several months if made of very acid resistant alloys like the chrome-nickel steels. Under such conditions copper-iron alloy and brass last but a few days or weeks. Rubber pipe or rubber lined pipe has good life as draw-off lines for the most corrosive colors and is often found to justify the extra expense. Durolite, a lined pipe, is being used successfully.

Filter press pumps, used for color making processes, are subjected to both corrosion and abrasion. For this reason they should be constructed of hard as well as acid resistant material. The nickel-bearing steel castings have been found quite satisfactory. "Ni-Resist" is now being used and is found to give good service.

It should be borne in mind that the manufacture of each color has its own peculiar corrosion problems and that the above statements necessarily have been, in the main, generalizations.

Rubber

By R. W. MOORHOUSE and J. J. HARTZ

*Chemical Engineering Division
Goodyear Tire & Rubber Co.
Akron, Ohio*

• IN THE MAIN it can be said that the processing of rubber involves the use of equipment in which the most important consideration is its strength. Pressure resistance and strength of construction characterize the equipment employed in reducing the highly elastic crude rubber to the more plastic state and then to its finished, compounded, vulcanized form; the pie-cutters, mills, Banbury mixers and molds are cited as examples.

Since the weight of processing equipment used is necessarily very high in order to supply the required strength, construction materials are, in general, iron and its less expensive alloys. It is, therefore, fortunate from the standpoint of pound-cost of equipment that rubber is non-corrosive because the use of expensive alloys would make equipment exorbitant in price. The cutting, milling, masticating, screening, compounding, calendaring and curing steps are dry operations and in no instance is there a condition which would be considered of a corrosive nature.

Rubber being soft and of a readily distorted structure does not introduce the problem of abrasion resistance, as is encountered in other industries such as the production of pigments and the like. While rubber itself is not very abrasive,

the problem of reducing wear on contact surfaces is always present. Tool steel is employed on the cutting edges of the cutters. For normal operation, breakdown and compounding mill rolls, as well as calender and refiner rolls, are constructed of chilled cast iron. In the rolls where extra high crushing resistance is required, steel with a hardened outer surface is employed. The alloy Meehanite is used at times when high working strength in castings is required. Pressure-curing heaters are of steel.

Stainless steel is preferable for piping, tanks and connections in the handling of organic compounding ingredients of an acidic nature, where the temperature is carried at a high enough point to cause corrosion of iron. As a rule, where contamination by rust in water dipping operations is detrimental, stainless steel or rubber lining is used.

In the reclaiming of cured rubber more problems are introduced. In the handling of reclaim scrap where abrasion is excessive, such as at the feed rolls of the hogs and grinders, Stellite coatings are employed. Boiler plate steel devulcanizers are used for caustic resistance at the beginning of the wet process. Monel metal, phosphor bronze, brass and stainless steel are used in screens and wrapping wires in the

dewatering operations. The material with the lowest stretch characteristic and coefficient of expansion is preferable. Where aqueous halogen coagulants and neutralizers are employed, tanks, piping and connections are rubber lined. In the dry processing operations of massing, milling and refining, the rolls are of chilled cast iron.

The tabulation below lists materials of construction that are used for some of the miscellaneous equipment involving the more severe corrosion problems of the rubber plant.

Equipment	Application	Materials of Construction
Pipes and connections	H ₂ S gas, hot or cold	Stainless steel
Processing tanks	Aqueous HCl, hot or cold	Haveg, Inconel, tantalum, carbon, Hastelloy B, special Pioneer
Pipes and connections	Anhydrous HCl, hot or cold	Haveg, nickel, tantalum, Hastelloy B, carbon
Plating racks	Electrolyzed (aqueous) H ₂ SO ₄ , NaOH, NaCN	Manganese phosphor-bronze, phosphor-bronze
Still	Distilled water of high purity	Block tin, aluminum
Processing tanks and fittings	H ₂ SO ₄	Durimet (fittings), Monel, wood
Processing tanks	(NH ₄) ₂ S ₂ O ₈ solution	Stainless steel
Reactors	Phenol	Stoneware
Still	Phenol	Block tin
Filter screens and dewaterers	Mild aqueous NaOH, mild H ₂ SO ₄	Monel, phosphor-bronze, brass

Salt

By C. D. LOOKER

*Director of Research
International Salt Co.
Ithaca, N. Y.*

• THE GREATEST difficulty with corrosion in the manufactured salt industry is in the grainer pans where the pipes are necessarily made of iron or steel and the walls and scrapers are of the same construction. The installation of Monel metal or other corrosion resistant alloys in these pipes would be very desirable, but the expense involved in their installation would seem to be almost prohibitive.

There is continuous corrosion of the pipes and casings in salt wells and, so far, our only recourse has been to keep



FOR PROCESS INDUSTRIES

replacing these pipes as they rust away. We have little or no corrosion problem in our vacuum pans which are of cast iron, often with copper tubes. Monel metal is eminently satisfactory in the centrifugals, filters, screens, packaging equipment, etc., as is indicated in the materials of construction supplement.

In the mining of rock salt, the mechanical equipment used consists largely of under-cutters, drills, electro-hydraulic shovels, shearing machines and mine locomotives. T. F. Courthope, general manager of the Retsof Mining Co., reports that as long as mine conditions are dry, there is no corrosion problem. The only exception is in the case of electro-hydraulic shovels, where metals coming into contact with salt water are often badly attacked. This corrosion takes place largely in the hydraulic elements, consisting of the piston rods and plungers. It is satisfactorily resisted by the use of high-chromium steel for the piston rods and Monel metal valve seats for the pump units. Most applications of corrosion resistant metals and alloys, however, are confined to the manufactured salt industry.

Sodium Hypochlorite

By JOHN H. BAKER

*Superintendent,
Tacoma Electrochemical Co.,
Tacoma, Wash.*

• IN MANUFACTURING concentrated sodium hypochlorite, the presence of even traces of iron is objectionable since iron compounds have been found to effect a decomposition of such solutions. Accordingly, iron is to be avoided wherever possible in the manufacturing process. From our experience over a period of years, concrete reaction and filter tanks, when properly constructed, give the best all-round service. Rubber-lined tanks are suitable if extreme care is used to bond the rubber lining to the steel. If, however, when applying the lining, the workman allows even a few pinholes to penetrate the lining, the solution passing through these openings attacks the metal, setting up a gas pressure between the lining and the tank which has a tendency to force the lining from the metal. This results in contamination and subsequent decomposition of the liquor.

Acidproof stoneware jugs or glass carboys were formerly used exclusively as shipping containers for sodium hypochlorite. Recently steel drums with detachable rubber linings have been perfected and are being used for the transportation of sodium hypochlorite solutions. The advantage of such a liner

resides in the fact that if any of the solution succeeds in penetrating the rubber, it can subsequently be removed when the container is returned for refilling. From the foregoing it is evident that materials of construction play an important part both in the manufacture and distribution of sodium hypochlorite.

Soda Pulp

EDITORIAL SUMMARY

• SODA AND SULPHATE (kraft) pulping processes present no major corrosion or abrasion problems to the

chemical engineer, with the exception of linings for the recovery furnaces. The sodium salts carried in the concentrated black-liquor are naturally corrosive to furnace linings, fusing with the brick and necessitating replacement after about one year of service. To prevent this trouble the standard commercial refractories that have been used include soapstone and chrome brick.

An interesting development has been a water-jacketed steel smelter, installed at Pacific Mills, Ltd., Ocean Falls, B. C., which after 18 months of service was reported as showing no indication of wear whatever. In addition to cutting maintenance costs this smelter produces in hot water the equivalent of 3,000 lb. steam per ton of pulp, which is available for use in the plant.

Soap

By OSCAR H. WURSTER

*Wurster & Sanger, Inc.
Chicago, Ill.*

• EQUIPMENT for the processes directly involved in the manufacture of soap is mostly fabricated of steel. This includes storage tanks for fats and oils, lye tanks, soap kettles, soap storage tanks and crutchers. In general, steel stands up satisfactorily in this service and manufacturers have not considered the additional cost of corrosion resistant materials as warranted.

Discoloration of soaps and the occurrence of rust particles resulting from the use of steel equipment is, however, a serious factor in the manufacture of high qualities of white soaps, such as white floating soaps, flake soaps and toilet soaps. In recent years some manufacturers have, therefore, installed kettles with the top sections lined with Monel metal sheets and kettles fabricated completely of nickel-clad steel.

Monel metal piping and steam distributing spiders were first used in soap kettles in 1924. Examination of this piping in 1933 showed complete absence of corrosion in this service.

Some miscellaneous equipment for soap production has been fabricated from metals which are more highly resistant to corrosion than steel. Stainless steel has been used for the tower construction for spraying soap powder. Monel metal has been used for soap crutchers.

Important uses of corrosion resistant metals are in the preliminary treatment and preparation of fats and oils for the soap kettle, in the splitting of fats and in the distillation of fatty acids.

Lead lined tanks for acid washing of fats have long been used. Twitchell

process fat splitting tanks have been constructed of steel or wood, lined with lead, but are usually of cypress wood, unlined. This service is unusually severe since the fat is boiled with water containing a low percentage of sulphuric acid. The fat and water levels change and the tanks are alternately hot and cold. The hot fat shrinks the wood and the hot water swells it. The cypress tanks are preferably mounted over lead trays to catch the leakage. Replacement of the tanks is rather frequent. For these reasons consideration has been given to fabricating these tanks of nickel-clad or stainless-clad steels, and the use of these materials will no doubt result in an ultimate economy even though of greater first cost.

Fat-splitting autoclaves were formerly fabricated of copper, although steel was used in some cases when the fatty acids were to be distilled. Monel metal has been used but more recent construction has been of nickel-clad and stainless-clad steel. The use of these new materials of construction permits the building of larger autoclaves and the use of higher pressures than was possible with copper autoclaves.

Recent installations of fatty acid distilling equipment have made extensive use of stainless steel, stainless-clad steel, nickel-clad steel, nickel and Monel metal for stills, condensers, separators and pipe lines.

There are numerous minor uses of corrosion and abrasion resisting metals in the soap industry but the above applications cover the largest requirements.

MATERIALS OF CONSTRUCTION

Sodium Sulphide

EDITORIAL SUMMARY

• **SODIUM SULPHIDE** is produced in the United States by two radically different processes. In the older process sodium sulphate—either niter cake or salt cake—is reduced with coal in a reverberatory furnace. The crude mass is leached with hot water after which the sulphide liquor is settled and run to iron crystallizing pans. Or in producing a fused product, the sulphide-containing liquor is run into cast-iron fusion pots and evaporated until it contains about 60 per cent Na_2S .

A more recent process is that em-

ployed by the barium chemicals industry where the raw material is barytes which is reduced in a furnace with coal to produce barium sulphide. The mass is leached with water and the solution treated with a sodium salt to give the desired barium product. When this has precipitated out a solution of sodium sulphide remains and this is evaporated and fused, or simply evaporated and sold as 28-30 per cent solution.

Except for the action of the fused materials on the linings of furnaces there is no serious materials problem. Cast iron suffices for the caustic pots and evaporators, and steel elsewhere. However, stainless steel has been suggested as a more satisfactory material for the evaporator tubes.

advantage in using aluminum or stainless steel. Again, there is insufficient experience to justify a comparison with copper.

Two materials are used for the slab pans, enameled iron and aluminum. Aluminum is better, but more expensive, so that enameled pans are generally used for the crude acid and aluminum for the finished product. Both cold and hot presses are made of ordinary steel. So far as is known, other materials have not been employed for this purpose.

For remelting the acid cake either unlined wood or wood or steel tanks, lead lined, are employed. There are indications that unlined cypress is fully satisfactory and it is certainly cheaper. The same situation holds in the case of the churns, where both lined and unlined tanks have been found suitable.

Brass, bronze, copper, aluminum, steel and wrought iron are among the materials used for the piping and pumping equipment. Both centrifugal and ordinary steam pumps are met with, bronze being the most suitable material for the stock end. Aluminum pipe is probably the best in that it seems to have the least effect on the stock, although brass and copper have both proved very satisfactory. Strangely enough, however, none of these metals seems to have worked out as a thoroughly satisfactory solution to the valve problem. Brass gate valves appear to be most used, and although the cause of considerable trouble are generally thought to be as good as anything obtainable. Replaceable seats and gates are said to be a worthwhile economy.

Stearic Acid and Red Oil

EDITORIAL SUMMARY

• **ANIMAL FATS** which are used as the raw materials for stearic acid and red oil are shipped and stored in steel, which, considering cost and availability, is probably the most satisfactory construction material. From the storage tanks the fats pass to acid washing tanks which are lead lined. Some concerns prefer steel tanks, others, wood, with lead linings. Both types have given complete satisfaction. No other lining materials have proven as suitable as lead. This, however, is not true of the saponifying tanks which also employ copper linings. These tanks are either of wood or of steel, lined with lead or copper. Although they are more expensive, copper lined tanks have been found to last longer. Still other concerns believe it preferable to use unlined cypress tanks, replacing them as frequently as need be. It is true that they do not last as long as lined tanks, but there seems to be considerable question as to the economics involved. In any case of unlined tanks it is to be noted that only the best grade of cypress is worth using.

Filter presses are employed for a number of purposes. For the sweet-water, ordinary cast iron plates are suitable while for red oil and stearic acid, an alloy of aluminum and silicon has performed satisfactorily. Tin-swiped copper for this purpose requires frequent retinning and is not considered satisfactory.

Evaporators of cast iron with copper tubes are very long lived. It is possible, however, that other types may be preferable. Stills for many years have been built of cast iron but, more re-

cently, other metals such as stainless steel, aluminum, copper and Monel metal have been introduced. However, experience with these is not yet sufficiently extensive to determine their relative merits. Very rarely do cast iron stills fail by being eaten away. Failure is generally by cracking.

Copper has been used for many years and with complete success for condensers, although there may be some

Sulphite Pulp

By J. D. MILLER

Chief Chemist, York Haven Paper Co.
York Haven, Pa.

• **AMONG THE GREATEST** corrosion problems of the entire pulp and paper industry are those to be found in the sulphite division. Here several troublesome chemicals are used in the processing of the fibers.

For digester linings, silica brick represents current practice. Patches of carbon brick of considerable size have been in continuous service in commercial digesters for over two years, without showing indications of failure. This material has possibilities, although the relatively high cost of the brick has retarded commercial application. Substitution of chrome-nickel steel in thin sheets for any type of brick is also of interest, as removal of the brick permits an appreciable increase in production per

cook. Steel lining has not progressed beyond use for experimental digesters, to date.

During the past few years, chrome-nickel steel castings have been replacing brass and bronze for digester fittings, to a large extent, and have been



FOR PROCESS INDUSTRIES

giving satisfactory service, particularly where all non-ferrous alloys are removed from the systems. Analyses conforming to specifications of the Technical Association of the Pulp and Paper Industry are finding most general acceptance. Although not generally used for sulphite service in this country, two other alloys may be mentioned, Avesta Metal (27 per cent chromium, 4.5 per cent nickel and 1.5 per cent molybdenum) which has found favor in Sweden; and the plain 27 per cent chromium alloy.

These alloys, being non-austenitic in structure, are free from the various grain-influencing factors which must be controlled as far as possible in the 18-8 type of alloy, to assure the best results in service. Small scale tests of these two alloys indicated them to be at least equally resistant to hot relief as the 18-8 type. These tests have been confirmed in part by a 2-in. Avesta valve which has been in service for eight months and two 2-in. elbows of 27 per cent chromium alloy which have been in service for 15 months, each unit apparently unaffected so far.

Steel pipe has likewise replaced the non-ferrous alloys, with 18-8 chrome-nickel steel being generally used. Although in service only a bit over a month, Avesta tubing and 27 per cent chromium alloy pipe appear unaffected, with the final answer to be given at some future date. Steel cover-liners, pumps, thermometer wells and flanges represent modern practice.

Perforated 18-8 chrome-nickel steel sheets are proving superior to either acidproof tile or wood for blow-pit bottoms. As they are non-plugging and less easily dislodged in service, pulp draining and washing are facilitated.

As the gas fan is handling cooled burner gas, the service is mild and hard lead fans last indefinitely.

Bleach-line life is to an extent a matter of operation, with common iron pipe suitable when the lines are kept full of liquid. It is imperative that iron contamination be avoided when handling bleached stock. Copper, wood and cement-lined pipe are used for this service.

Owing to superior strength and corrosion resistance, blow-valve stems, relief strainers and relief valves are now of chrome-nickel steel, replacing bronze as in the case of digester fittings. This is again particularly true in cases of elimination of all non-ferrous alloys.

Materials for beater bars and bed plates are to an extent governed by the quality of stock handled. For unbleached stock, plain steel will find favor, although an alloy steel of up to 14 per cent chromium is frequently specified. The additional cost is justified by greater resistance to the acid corrosion of the beaters, which in extreme cases

will reach a pH of 4.2. This acidity comes from the aluminum sulphate used for sizing. In the case of bleached stock, beater tackle will be of material to avoid iron contamination, and bronze or the chrome alloy steel will be used.

Fourdrinier wires represent the greatest single metal cost in the paper industry, naturally applying to mills using the fourdrinier type of sheet forming equipment. Although the wire manufacturers have exercised great in-

genuity in designing different types of weaves and methods of seam forming, thereby tending to increase wire life, to date the metals having satisfactory properties for wires are limited to copper, brass and bronze, the latter being used particularly on the high speed machines. When it is considered that wire cost per ton of product will vary from \$0.25 to \$0.50, a mill making 500 tons of paper a day would welcome a wire that would increase service life 25 per cent.

Sulphuric Acid

By THOMAS R. HARNEY

Monsanto Chemical Co.
St. Louis, Mo.

• DURING RECENT YEARS there have been no really important developments in construction materials for sulphuric acid manufacture. In the purification type of contact plant, that is, one that is operating on pyrites or metallurgical gas, nothing better than cast iron has been found for the preliminary cooling of roaster gases and nothing better than lead for the final cooling and handling of gases up to the drying towers. Water-sprayed lead coolers have, for the most part, been abandoned. In their place irrigated towers of steel, with a lead lining, have been used instead of the externally-sprayed cooler. In some cases this type of tower is used, lined with brick instead of lead, and in such a case this tower takes the place of most of the cast iron cooling.

As formerly, sulphur burners employ a steel shell, with or without a firebrick lining. Fines burners are also of steel with cast iron rabbles and firebrick lining.

Lead has largely been eliminated in the drying towers by the use of 66 deg. instead of 60 deg. Bé. drying acid. These towers are now usually constructed of steel with an acidproof masonry lining. Opinion differs as to the best type of packing for cooling, scrubbing and drying towers. Some engineers prefer no packing at all in cooling towers, using sprays instead. There is pretty general agreement, however, on the use of some type of ring packing for scrubbing towers. Various packings, including rings, broken quartz, quartz pebbles, and even brick, are employed in drying towers. Each probably has its advantages and disadvantages.

There is as yet no unanimity of opinion in regard to the proper type of blower, some designers preferring the cast iron, positive-pressure type, while others use the high-speed turbo blower. There are indications that an alloy runner should be used in the latter.

Steel for converters is now a definite tendency in the United States, rather than the cast iron of older American practice. The change is due partly to cost and partly to the fact that larger and larger converters are being built, having now reached a point where the shipment of the castings would be prohibitive. Steel converters have now been in successful use for several years, without evidence of the corrosion or oxidation that were formerly feared. They have, in fact, been used in Europe for many years.

Practice in heat exchangers has not been altered for a long time, to my knowledge. Were it not for their cost, however, there is evidence that some of the chrome steels might well be used for heat exchanger tubes.

Cast iron has practically been eliminated as a material for absorber shells, again owing to the increased size of units. In their stead brick lined steel shells are now almost universal practice.

For acids below 60 deg. Bé. in strength, hard lead or some of the weak-acid resisting alloys are used for pumps. For acid not much below 60 deg. and for greater concentrations, cast iron is the material used, except for external oleum pumps in which case steel or one of the special high-strength alloys is safer. Cast iron is satisfactory for submerged oleum pumps, however.

Coolers and piping for acid of 60 deg. strength or less are still constructed of lead. For acid of 60 deg. to 98 per cent strength both coolers and pipe lines should be of cast iron, while for oleum, extra heavy steel is most satisfactory.

Chemical lead continues to be the most important material in the chamber plant and is used in the construction of the chambers and for the pans and curtain walls of Glover and Gay-Lussac towers and as lining for wood or steel storage tanks. Hard lead pumps and lead lined

MATERIALS OF CONSTRUCTION

blow cases suffice to move the acid. Next in importance is chemical tile which is used for the lining and packing of the towers and sometimes for the lining of steel acid tanks.

Tannic Acid

EDITORIAL SUMMARY

• **CURRENT PRACTICE** in the selection of the best construction materials for equipment used in the manufacture of tannic acid extracts has not changed in recent years. The principal requirement is that no iron or steel material be used, owing to the formation of iron tannates which even in minute quantity ruin the product from a color standpoint. Accordingly, copper alloys are used which do not form dark colored compounds with tannic acid. The particular alloy to be used is determined largely by cost considerations. Other materials, such as nickel, are suitable but not employed on account of higher cost. In the larger and heavier apparatus such as the pressure extractors or autoclaves, straight copper is used exclusively. The fittings for these vessels are made of brass. Vacuum evaporators are made of copper, bronze or brass. Pumps and pipe for handling the tannin extracts are generally either bronze or brass.

Wood has been found to be satisfactory for construction of storage and processing tanks and tubs. The steel tank cars for shipping the extracts are

given a coating of a special acid resisting paint to prevent corrosion. The industry had an abrasion problem that was solved by the use of Stellite and Stoodite on chippers and shredders.

Tartaric Acid

By F. M. SKIDGELL

*Superintendent, Tartar Chemical Works
Royal Baking Powder Co.
Brooklyn, N. Y.*

• **NO SERIOUS CORROSION** problems exist in the tartaric acid industry today. This should not imply that the problems do not exist, but rather that they have satisfactorily been met with available equipment, suitably installed and built of materials adapted to the requirements. Only when these dictates have not been followed has trouble been encountered. Properly made and used, equipment is certain of long life.

Until fairly recently evaporator tubes gave difficulty, but this trouble has now been taken care of nicely through the use of recently patented perforated steel tubes coated with lead. Lead is suitable, together with wood, for early stage liquors. For the concentrated liquors aluminum and stoneware are satisfactory. Pumps of Duriron, bronze, and a special chrome-nickel steel, and wooden filter presses, cover all requirements. Aluminum and Monel metal have both been used successfully for crystallizers, while hard lead is the best material for evaporator bodies.

of steel, and the filter presses of cast iron, with Monel metal or cotton cloths.

The spinning department presents a more difficult problem since it involves the handling of mixtures containing dilute sulphuric acid. Heavier parts of the spinning machines are made of cast iron, covered with lead for the protection of those parts most directly subject to acid attack. Other cast iron parts are protected with acid-resisting paint. Wood is used to some extent, as in the pot compartments of pot spinning machines. Lead is used for the spinning troughs and for acid lines, as well as for the equipment for spinning bath preparation and recovery. Rubber-lined vacuum crystallizers have recently been used, according to reports, in the recovery of glauber's salt from spent spinning bath. The same source is authority for the mention of the use of nickel tubes for evaporators and heaters in spinning bath recovery.

Viscose is conducted to the spinneret through iron lines leading to spinning pumps of cast iron and steel. From the pump the solution passes through a hard-rubber candle filter, with a Monel metal or cotton filter fabric, thence through a hard lead—or occasionally glass—tube to the spinneret which is made generally of some alloy of platinum and gold; gold and nickel, ruthenium or palladium; or gold or platinum and iridium. Tantalum has also been advocated as a spinneret material. Other materials that have been used to some extent include glass, china and porcelain.

Either glass or porcelain is used for thread guides, and hard lead for guide supports. Feed wheels (godets) are made of glass, hard rubber or phenol-formaldehyde plastic. Spinning bobbins are of glass, or of metal, such as aluminum or lacquered iron, while spinning pots are of phenol-formaldehyde plastic in most cases. Ebonite-lined aluminum pots have also been employed, particularly before the advent of the plastic pot.

In plants employing wet reeling of pot cakes, the swifts are generally of stainless steel. Other plants, in which washing is accomplished in the cake, support the cakes on rods of glass, hard rubber, nickel, or Monel metal. Centrifugals for wringing the cakes have baskets of any suitable rustless metal

Viscose Rayon

EDITORIAL SUMMARY

• **MOST OF THE** construction materials employed in the viscose rayon plant are fairly standard throughout the industry although individual preferences account for certain variations. Perhaps the simplest way to list these materials is to follow through the process from raw materials to finished yarn, noting at each step what resistant materials are most commonly employed.

Of the raw materials only caustic soda introduces a particular problem and this, strangely enough, was not thought to be a problem a few years ago. Prior to that time the caustic was shipped to the plant either as the solid product, in one-trip steel drums, or as liquid, in steel drums or tank cars. However, as more attention was paid to iron contamination it became desirable to safeguard the caustic from becoming a pos-

sible contamination source, with the result that nickel-lined steel tank cars are now generally used for the purpose. With the exception of hydrochloric acid, which is received in glass carboys or rubber-lined drums or tank cars, the other raw materials are brought in in steel, or in box cars, depending on their nature.

In the chemical end of viscose manufacture cast iron and mild steel suffice for most of the equipment. Steeping presses are of cast iron with sheet iron, or more recently, Monel or nickel separator plates. Shredders and ripening cans are of cast iron and sheet iron, respectively. Barrattes are generally of cast iron, with nickel plate, wood and aluminum also used. Viscose mixing and blending tanks, as well as the tanks used for the aging of the solution, are



FOR PROCESS INDUSTRIES

such as aluminum, nickel, Monel metal or bronze. The desulphuring step, at whatever point in the process it may come, involves no particular difficulty. The dilute sodium sulphide that it used is not corrosive to iron, although it adversely affects nickel and its alloys. Hence the cakes or skeins are hung on

glass, hard rubber or rubber covered rods which are also suitable for the washing and bleaching steps, if these are carried out at the same time as the desulphuring. For wash and bleach purposes the catch tanks are of wood, lead or stoneware and the showers of brass, aluminum or Monel metal.

White Lead

By **ANDREW MAYER, JR.**

*Chemical Engineer, National Lead Co.
Brooklyn, N. Y.*

• **WHITE LEAD**, in the United States, is made chiefly by the Old Dutch and Carter processes, in which pure metallic lead is converted to basic carbonate by the action of oxygen, carbon dioxide, water and acetic acid. Problems involving corrosion of equipment occur mainly in converting to carbonate and in handling white lead water pulp. Metallic lead, dry white lead and white lead-in-oil are neither corrosive nor abrasive and are handled satisfactorily in cast iron and steel equipment.

The walls of the modern Dutch Process stack are constructed of wood and reinforced concrete. They are protected from the corrosive atmosphere within by a banking of spent tan bark and by the slow infiltration of air. The stack is "set" with spent tan bark; hard burned clay pots containing the lead "buckles" and dilute acetic acid; and wooden boards which should be reasonably free from rosin and extractive matter that would discolor the carbonate. This service is severe and the boards last only about nine months. The clay pots are not affected by corrosion and the main problem here is breakage.

The rolls, screens, etc., used for separating the basic carbonate from unconverted metal are of cast iron and steel.

The Carter process cylinders, in which "atomized" metallic lead is converted to carbonate, are built of wood, best quality long leaf yellow pine being very suitable. The pipes for distributing carbon dioxide, which is made by burning coke, may be of cast iron or steel if the gas temperature is kept above the dewpoint, but where the gas is scrubbed with water, to remove traces of sulphur dioxide, wood stave pipe with cast iron connections is preferable. It should be kept well painted outside.

In handling white lead water pulp, the corrosion and abrasion concern not so much the wear of equipment as the possibility of discoloration of the product. Cast iron and steel are used to some extent for equipment where the

pulp is kept moving, but such equipment, after a shut-down, must be washed out with water before again being put into service, to avoid contamination with rust. Rubber covered cast

iron has been used with success for some machines.

In general the materials used in most equipment for handling, and especially for storing, the pulp are wood, copper, brass and bronze. Typical tubs and classifiers are of cypress, inside parts such as stirrers of white oak, or brass and white oak. Steel shafts are covered with brass sleeves and piping is of brass. Pumps are mainly single-suction centrifugals; here abrasion is of some consequence and hydraulic bronze has proved satisfactory both for casings and impellers.

Steam-jacketed drying pans are built of copper, with steel jackets. In more modern dryers of the festoon type, the belt is woven bronze wire.

As white lead-in-oil may contain traces of moisture, the steel containers in which it is packed are coated inside with baking varnish to prevent possible discoloration of the product by rust.

Wood Rosin and Turpentine

EDITORIAL SUMMARY

• **PERHAPS** the outstanding improvement in the naval stores industry, from the standpoint of construction materials, has been the substitution of chrome-nickel steel for the ordinary low-carbon steels used in the extractors. Here the wood chips for the steam-distillation, solvent-extraction process are first steamed for turpentine or subsequently to remove the petroleum solvent. The vapors, containing acetic acid, are extremely corrosive to ordinary steel, especially where condensation occurs and the acid is concentrated. In the experience of one American company, the ordinary steel extractors would last approximately five years. A number were replaced two years ago with chrome nickel steel at a cost of more than three times the previous installation. However, after two years of continuous service, the stainless steel extractors show absolutely no sign of wear.

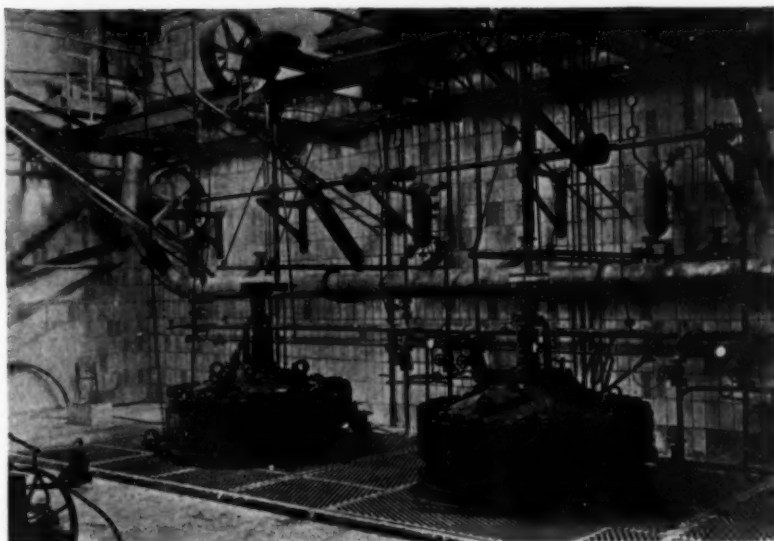
In the case of the steel extractors, corrosion within the extractor itself was largely localized around the rivets, if that type of fabrication had been employed. Welded construction is much more satisfactory according to Croswell and Rockwell, whose paper on the chemical engineering features of the naval stores industry was presented before the A.I.Ch.E. convention in New Orleans in December, 1930 (See *Trans. A.I.Ch.E.*, Vol. 25, p. 177-200). This article contained an interesting section on corrosion and erosion problems of the wood naval stores industry.

These authors also emphasized the fact that after the vapors leave the extractors and enter the pipe line, they are too corrosive to make the use of steel practicable. Pipe lines and condensers are made, therefore, of copper or brass and the valves and fittings are cast of brass. It should also be noted that aluminum has proved very satisfactory in the pipe lines, condensers and storage tanks in which the various distillates are stored.

Since the prevention of loss of solvent from leaks is important, care must be taken to use proper packing for pipe joints and valve stems. Most packings are unsuitable for this work, since the naphtha will dissolve out the ordinary lubricants with which the packing is impregnated. Croswell and Rockwell report that, in general, for pipe flanges a long-fibered, asbestos-compounded sheet packing is used. A stitched hydraulic packing is best for the pistons of inside-packed reciprocating pumps such as are used for handling the solvent naphtha. For valve stems, a 90 per cent pure asbestos yarn impregnated with graphite is said to give best results.

Another point of attack by corrosion occurs in the steel settling tanks used to separate the oil or solvent from the water. Obviously, most of the acid is concentrated in the water layer and, as a result, the lower portions of these tanks corrode so rapidly that they must be replaced with new equipment every few years.

Acidproof wall plates and floor tile in a chemical processing room



GOOD RESULTS with acidproof masonry requires careful attention to the details of the design and construction. The average chemical engineer's knowledge of the subject does not compare favorably with his knowledge of other types of construction; and, as a consequence, materials are often specified which are neither as economical, nor as permanent as properly built acidproof masonry.

The difficulties encountered in the applications of acidproof masonry in the process industries are mechanical rather than chemical. Properly selected chemical brick and acidproof cement resist practically all chemicals. Important exceptions are: strong alkalis, and fluorine compounds, the former reacts with the silica of the brick and cement to form soluble silicates, while the latter combines with the silica, to form silicon fluoride.

Although there are firms of chemical contractors who specialize in acidproof masonry construction, it is desirable for the plant engineer to have a working knowledge of the subject, and it is hoped that a discussion of certain salient points may be of interest.

Acidproof masonry construction may be conveniently divided into all-masonry structures, such as acid towers; and masonry-lined units, such as autoclaves and storage tanks. All-masonry towers in acid plants are well known. The use of acidproof masonry lining in metal shells, to protect the metal from corrosion, is, however, a more modern development. Although a somewhat different technique is employed in the two cases, there are certain requirements which are common to both types.

It should be recognized that all masonry is porous, this being true as to both the brick and the jointing materials. In carefully constructed masonry this will be shown in weeping, and wet surfaces. Carelessly done work may be expected to leak badly. The means of overcoming this inherent difficulty will be detailed hereafter.

Acidproof masonry is frequently subjected to extremely heavy superimposed loads, and the structure must be designed accordingly. Raschig rings in a reaction chamber, for example, impose a considerable load on the bottom, and, similarly, in a Gay-Lussac or Glover tower, the weight of the packing must be taken into account in designing the supporting pilasters. Although good

chemical brick have a crushing strength of more than 5,000 lb. per sq.in., pilasters not infrequently fail long before the expiration of their normal life. This is, of course, partly due to the deterioration of inferior brick, but even in these cases more conservative design would extend the useful life of the structure.

Capacity requirements will of course determine size and shape, and although the advantages of acidproof masonry in small equipment are limited, it is used in even the smallest vessels, to prevent product contamination. On the other hand, tanks are common. All-masonry structures, particularly acid towers, have been successfully built in sizes varying from 4 to 16 ft. in diameter, and 8 to 60 ft. in height.

The forces set up by expansion and contraction must be guarded against if any considerable temperature range is expected. These forces are distributed principally in the joints of the brickwork. Hence, thick walls with multiple courses of brick are best where there is a large drop in temperature across the wall. Another advantage in using more than one course of brick is the fact that the masonry is unlikely to open up at the same point in the different courses. This is especially true if the joints are broken or staggered as

they should always be in first-class work. Round tanks and towers are to be preferred, as the forces of expansion are more evenly distributed.

No less important than the temperature range is the rate of temperature change. A rapid change sets up localized stresses which, in extreme cases, cause the masonry to crack and spall. A quick change, over a relatively small range, is more destructive than a wide temperature change which takes place slowly. Manufacturers of chemical stoneware advise a rate of change not exceeding 2 deg. C. per min. Wherever possible the same rule should be applied to acidproof masonry. If a high rate of change of temperature is expected, a brick more porous than standard chemical brick should be selected.

In the construction of all-masonry acid towers the porosity of the brick work is overcome by building double walls, with a small air space between them. This type of tower is best built of perforated acidproof radial brick. The circular construction distributes the strains uniformly and any acid seepage which may develop drains down the air space and is returned to the tower proper. Towers built in this manner have been in service for ten years and are still in good condition.

The most suitable tanks to line with

ACIDPROOF MASONRY CONSTRUCTION

By **RICHARD B. SHERIDAN**

*Alphons Custodis Chimney Construction Co.
Chemical Construction Division
New York, N. Y.*

acidproof masonry are steel or concrete. It is imperative to ascertain that the shell is liquid tight and rigid before installing the lining. Otherwise acid will pass through the masonry and destroy the retaining walls. Concrete tanks should first be lined with liquid tight asphalt membranes.

In the case of steel tanks acidproof masonry linings provide complete protection against many chemicals if the steel is carefully plastered with a $\frac{1}{4}$ -in. layer of a chemically setting acidproof cement. This layer of cement prevents the circulation of acid between the brickwork and the steel. Corrosion is limited to a surface effect where the formation of insoluble salts clog the pores of the masonry and prevent the further penetration of acid. Steel lined with homogeneous lead or rubber is also used in some cases.

The outlets, in tanks lined with acidproof masonry, require special attention. The use of arch brick around the stoneware pipe insures tight joints.

One of the most satisfactory applications of acidproof masonry linings is the surfacing of concrete floors and walls, by means of a single course of brick or tile, with an asphalt membrane between the concrete and the brick. Such floors cost approximately 60c. per sq.ft., and, once installed, require no further attention. If the floor is subject to heavy trucking, the brick should be laid on edge. A water-resistant acidproof cement should be used. This construction also is suitable for sewers and drains.

The choice of chemical brick for a particular purpose should be made on the basis of comparative tests of the brick available. "Chemical brick" is a general term and has been used loosely to include all varieties from hard-burned common brick to those made

from carefully selected washed clays. This is demonstrated by the fact that chemical brick in some acid towers lasts for 20 yr., while others, under substantially the same conditions, fail within 4 or 5 yr. The burning of the brick greatly influences the acid-resistance of the body from which it is made. Hence, tests should be made to determine its resistance to the particular chemical to be handled. These will include determinations of acid-solubility, and porosity, as ultimate analyses are of little value. In general, however, the iron content and free alkali should be low. Brick high in silica are best for handling hydrochloric acid. Many manufacturers of sulphuric acid prefer a dense, hard-burned shale. A thoroughly burned clay brick, of low porosity, is satisfactory for general purposes. Where there is a possibility of the formation of crystals which exert pressure in the pores of the brick, a particularly dense body should be specified and the brick should be salt glazed. Since fluorine affects all ceramic materials, wherever appreciable quantities of hydrofluoric acid or fluorine are present, carbon brick should be used.

Manufacturers of chemical brick generally stock those shapes most in demand, but are prepared to make up such other shapes as may be required. Standard shapes, such as circle brick, arch brick, split brick, and straight brick, should be used where possible, since special shapes require a special mold or die, and this is often an unnecessary expense which may be avoided by judicious planning.

The selection of a bonding material is a matter requiring careful consideration, for there are available a number of acidproof cements of varying characteristics. Mixtures of silicate of soda

and silex are best known. These cements are inexpensive, but have the disadvantage of setting slowly, and incompletely. They are suitable only for concentrated acid conditions. Chemically setting silicate cements which are resistant to water and dilute acids as well as the most concentrated acids are also available. They have the additional advantage of setting rapidly, and are prepared by mixing a quartz powder containing an acid salt with silicate of soda. The reaction precipitates silicic acid, the gel being subsequently dehydrated so that the joint, after the soluble sodium salts leach out, is nearly all silica. Cements of the Bakelite type which set at normal temperatures, are excellent in many cases, although more expensive than the silicate cements. Sulphur and sand mixtures are used to some extent, but are difficult to work with since they must be handled as a liquid. Glycerine-litharge cements are extensively used in pulp and paper mills for lining digesters.

Workmanship is an important part of a successful installation. Only a careful mason, who has had some experience around a chemical plant can produce first-class results. It is advisable for the engineer in charge to issue detailed written instructions.

Acidproof masonry has been used successfully in acid towers and concentrators for many years. It is, of course, well known in the paper industry, as a lining for sulphite digesters. A less well known application is for fat-splitting tanks, and floors in oil and soap plants. In the petroleum refining industry it is finding favor in the handling of sludge acid, and untreated gasolines. In Europe ammonia saturators in coke oven plants are also lined with chemical brick.



STAINLESS-CLAD CONSTRUCTION

SOME of the largest stainless-clad steel plates ever produced in this country entered into the fabrication of a 35 ft. rotary dryer recently built by C. O. Bartlett & Snow Co. from plates produced by Ingersoll Steel & Disc Co. Several of the plates were approximately 5x20 ft. x $\frac{1}{4}$ in. The stainless cladding was approximately 0.05 in. thick, and was composed of 18-8 Cr-Ni steel, which was connected at the joints by electric welding.

The end retainer plates were solid Allegheny metal. They were secured by stainless steel angle rings and rivets. The discharge end retainer plate was

fitted with several removable door plates, secured by stainless steel bolts and nuts.

The cast iron sealing rings at each end of the dryer, where the cylinder entered the breeching, were protected by stainless clad plates electric welded together and secured to stainless angle rings with stainless rivets. To insure that no ordinary steel surface contacted the wet or dry material processed, the mild steel exterior of the cylinder was covered with a strip of stainless steel, the edges of which were swedged over the ends of the cylinder plates and joined to the stainless cladding by electric welding. A rotary cooler was sup-

plied with the dryer. It was fabricated from heat treated aluminum alloy 51ST.

The dryer, cooler, and breeching equipment was so made that no surface was exposed to the stock being processed, except stainless steel or aluminum alloy, thus insuring a dried stock of the highest chemical purity. Stainless steel was chosen for the dryer and breechings because of the high resistance to both corrosion and abrasion. The aluminum alloy of the cooler had practically the same surface hardness as steel, resisted both abrasion and corrosion, and at the same time by its high heat conductivity increased the cooling.

CEMENTS FOR CORROSION, HEAT AND SOLVENT RESISTANCE

By THEODORE R. OLIVE

Associate Editor, Chem. & Met.

IT HAS OFTEN been stated by engineers whose experience qualifies them as experts in cements for chemical plant use, that no one person knows more than a small part of the story of jointing materials. The truth of this statement becomes increasingly clear the farther one delves into the subject; and the farther one delves, the more he doubts whether any person is ever likely to know the whole story. Cements are legion. Their properties run the entire gamut of resistances and their varied characteristics suit them for every conceivable purpose. Obviously, then, what follows can touch only on a smattering of the best known types, with emphasis on those which experience has shown to be most broadly useful.

Except in so far as they serve for solvent and corrosion resistance, cements used chiefly for building purposes will not be included here. Nor will it be possible to touch more than briefly on high temperature cements used only for heat resistance. Those materials with which the chemical engineer is primarily concerned are the ones used for jointing resistant masonry and stoneware shapes, for making liquid- or gas-tight joints between metals and non-metals, for making up pipe threads and gaskets, and for producing resistant surfaces on equipment in contact with deteriorating substances. He is concerned with materials for producing relatively permanent joints, referred to as "cements," and with other substances for joints of a more temporary character, usually called "lutes." In general, cements set up to a more or less rigid mass, while the average luting material remains relatively plastic or elastic, permitting its ready removal.

Cement Classification

No thoroughly satisfactory method of classifying chemical cements and lutes seems ever to have been made, so that only rough classification will be attempted here. Again generalizing, it may be said that the majority of cements are inorganic—but there are many exceptions. Lutes, however, are usually composed of an organic binder and one or more inorganic fillers. In some groups it is possible to make a classi-

fication on the basis of the binder employed, but in others, the binder is indistinguishable from the filler. Probably, then, the simplest and most useful system for examining the cementing materials is to divide them into broad groups where possible, with an addenda of unique but well known mixtures.

By far the greatest part of chemical plant cementing and luting is accomplished with a comparatively small number of materials in various combinations and proportions. Hardening of cement may be of three types: either by the evaporation of water or another solvent; by cooling; or by chemical reaction. Sometimes the setting is a combination of these. Materials most common in cements include, as binders, sodium silicate and sulphur, and such organic materials as asphalts, pitches, tars, shellac, glue, rubber, glycerine and linseed oil. Practically any inert material is useful as a filler. Among those most used are ground chemical stoneware, burned or unburned fireclay, ground firebrick, silix and ground quartz, talc, white sand, whiting, china clay, portland cement, asbestos, powdered glass, barium sulphate, litharge, red and white lead, and infusorial earth.

For special purposes other materials include plaster of paris, magnesium compounds, iron powder and sal ammoniac, synthetic resins, pyroxylin type compounds and casein.

Proprietary vs. Home-made

Practically any cementing or luting requirement can be met with one of the numerous proprietary compounds on the market. Unfortunately, many of these compounds contain about two parts of mystery for each part of cement, and some are over-rated and over-priced. Nevertheless, they have their advantages, among which is the evident one of convenience, for they are supplied either ready to use or requiring only a small amount of preparation. Particularly when only a minor job is contemplated, few users wish to take the trouble of assembling the necessary ingredients and preparing them as they must be prepared. Furthermore, this preparation usually involves considerable experience and experiment and, in

some few cases, depends on patented procedures or on mixtures that are actually unknown outside of the establishment of the maker.

From the foregoing, it should be evident that price alone will ordinarily be the only deterrent to the use of proprietary compounds. Even this may not be a factor since at least one of the large stoneware manufacturers follows the policy of supplying cements of stated composition, depending on his experience and volume of production to produce better, cheaper joints than the customer can make with home-made cements. Hence the writer's attitude is that, while proprietary mixtures are usually somewhat more costly, in most cases their use is to be preferred; nevertheless, few chemical engineers know as much as they should about cements. With more extensive information at hand, they should be better situated to choose the more suitable types and to determine whether to purchase those they need or "roll their own."

Sodium Silicate Cements

Cements which depend upon sodium (or occasionally potassium) silicate for their principal active ingredient are used more than any other for resistance to acids, other than hydrofluoric. Properly compounded, they are resistant to weak as well as to strong acids, to acid and neutral salts in solution, to water and steam, hydrocarbons and the halogens. With the exception of ammonia and bleaching powder solutions, they are not suitable for alkalis. They exhibit good adherence to ceramic materials, metals, wood and glass.

Sodium silicate, in itself, is a cement although it is never used alone except as an adhesive for paper, veneer and the like. As is well known, the name refers not to a single compound, but rather to a range of water soluble glasses containing various ratios of soda to silica ranging from $\text{Na}_2\text{O} \cdot 4\text{SiO}_2$ to $2\text{Na}_2\text{O} \cdot 3\text{SiO}_2$. The properties of these compounds, both chemically and as adhesives, vary widely. Since, in contact with acids, the alkalinity is removed by leaching, only the most siliceous compounds are used, the one having a com-

position of $\text{Na}_2\text{O} \cdot 3.86\text{SiO}_2$ being that generally recommended for acidproof cement. For some purposes, however, ratios as low as 1.2 are used in chemical plant work. Recommendations made by the Philadelphia Quartz Co. appear in the accompanying tabulation.

Ordinarily, water solutions of sodium silicate are employed in cement making and are either mixed with the filler materials at the time of use, or they may be incorporated with the fillers by the cement maker and the cement shipped in air-tight containers to prevent setting by the loss of water. Silicate solutions as ordinarily supplied are very nearly saturated and the loss of 5 to 10 per cent of water will cause an initial set. The final air set is attained when 15-20 per cent of moisture remains.

All sodium silicates are to some extent water soluble. Certain of them can be supplied as hydrated dry powders which are more or less readily water soluble. It is through the use of such silicate powders that some of the proprietary cements can be supplied dry, requiring only mixing with water before use.

Setting of Silicate Cements

Silicate cements set in two ways. Any silicate solution will eventually dry out to 15-20 per cent water content in contact with the atmosphere, a process which is hastened by heat. The result is a glass, still somewhat water soluble, which serves as a strong bond between whatever filler materials are used and the bricks or other surfaces to which the cement is applied. After this preliminary air set, the cement is ordinarily given an acid wash to convert as much as possible of the silicate binder into silicic acid which, in turn, loses water and reverts to silica. The change from dried silicate to silicic acid materially reduces the strength of the cement, but tends to prevent its being washed from the joint in service. For most purposes, however, what strength remains is more than ample.

It should be noted that in the case of ordinary silicate cements in which an acid treatment is necessary to effect conversion to silicic acid, sufficient penetration of the acid is not attained, and on this account such cements are not suitable for resistance to weak acids and solutions, water and steam. In the case of some of the newer proprietary cements, both a quick set and complete resistance to water and steam are attained by incorporating with the cement an acid or alkaline ingredient, or both, which will react with the silicate to form some insoluble compound. Such cements do not require an acid wash except in special cases.

Many filler materials have been employed with silicate solutions. Among

Silicate Solutions for Chemical Plant Cements

(Philadelphia Quartz Co.)

$\text{Na}_2\text{O} \cdot \text{SiO}_2$ Ratio	Degrees Baumé	Approximate Softening Temperature, Deg. F.	Typical Uses
1:3.86	33.5	2,000	Towers, concentrators
1:3.22	41.1	1,575	Heat and acid resistance
1:2.44	52.0	1,525	Digester linings
1:2.00	59.1	1,600	Digester linings

them are ground chemical stoneware, clays, barytes, talc, asbestos, powdered glass, steatite, porcelain and various forms of silica such as silex, quartz, flint and sand. A small amount of portland cement is sometimes added to attain a quick set. A very important consideration in securing adequate strength of the cement hinges on the size of aggregate materials used. For example, Snell and Farkas (*Ind. Eng. Chem.*, 25, 1931, p. 525) quote the following screen analysis of the siliceous filler used in one successful commercial cement:

	Mesh	Per Cent
Retained on	20	0.02
	40	0.41
	60	2.69
	80	2.37
	100	6.63
	200	17.38
Through	200	70.50

Another recommended screen analysis is one-half 20 mesh and one-half 100 mesh and finer.

A great many formulas have been recommended in the literature for various purposes. There is so little apparent relation between them that one gains the impression that nearly every cement user must have evolved his own favorite variety. Some of them are:

- 50 lb. silica (20 mesh)
- 50 lb. silica (100 mesh and finer)
- 70-100 lb. 1:3.86 silicate, 33½ deg. Bé.

This is recommended for general acid-proof masonry work, as is the following:

- 20 parts pulverized silica
- 12 parts English ball clay
- 4 parts powdered, hydrated sodium silicate of ratio 1:3.22
- 9 parts water

A mixture for sulphite digester linings is:

- 20 parts 20 mesh quartz
- 1 part portland cement
- Silicate solution of 1:2.44 ratio to proper consistency.

The addition of water hastens the set. This cement requires careful drying. A cement said to be excellent but expensive is:

- 8 parts litharge
- 4 parts silicate solution of 1:2.44 ratio, diluted to 30 deg. Bé.
- Plus glycerine.

The quantity of glycerine determines the setting time. With one part, the setting time is 3 minutes, two parts 6

minutes, three parts 10 minutes and four parts 25 minutes.

A mixture for dilute hydrochloric acid is a paste of one volume of china clay, two of fine white sand or powdered quartz made up with 30 deg. Bé. silicate. The addition of fine casein equal to 5 per cent of the silicate is said to improve the water resistance of the cement. Silicate of 30 deg. Bé. made into a paste with whiting or barium sulphate are other mixtures. Still another substitutes precipitated magnesium carbonate for the filler materials mentioned. A reaction is involved in this case and the addition of one or two parts of water to the 30-deg. silicate is said to reduce the setting rate.

For chlorine, one recommended mixture contains one part each of powdered glass, portland cement and diluted silicate solution. A jointing for glass to glass is composed of 3 parts of asbestos powder, 1 of precipitated BaSO_4 and sufficient 50-deg. Bé. silicate solution. A cement for brick to lead employs silex and 40-deg. Bé. silicate. A cement for hot nitric acid contains 1 part of sand, 1 of asbestos and 2 of silicate solution, while another is 2 parts of asbestos, 3 of BaSO_4 and 2 of silicate solution.

Quick-Setting Silicate Cements

As a general rule, most silicate cements require 70-100 lb. of silicate solution per 100 lb. of filler materials. The success of the cement depends to a great extent upon proper curing and most of the ordinary mixtures take from 7 to 10 days or even longer to attain a satisfactory air set. In fact, air drying for fully 30 days is required for maximum strength. The time depends upon the rate of water evaporation, and this is determined both by temperature and by humidity. Because of the time required for setting of ordinary cements, therefore, the newer quick-setting mixtures are rapidly gaining in favor. According to Snell and Farkas (*ibid.*) such cements contain minor percentages of acid (or materials giving an acid reaction in solution) which will react with the silicate to yield colloidal silica; or alkaline or neutral materials which react with silicate or silicic acid to produce an insoluble silicate and water or a neutral salt. The acid types use organic acids such as oxalic or stearic or salts such as fluosilicates; the basic types, hydroxides such as aluminum hydroxide; and the neutral types, neutral salts or mixtures of basic and acidic salts. These authors tested the three quick-setting types against ordinary silicate cement and found the alkaline type to be workable for 20 minutes, the neutral type for 15 minutes and the acid type for 10 minutes. Herein lies one of the difficulties with quick-setting ce-

ments: once they no longer adhere to the brick or trowel, setting has progressed too far and the remaining cement must be discarded.

As none of the chemically cured cements requires drying out to attain a set, they produce a good bond at the end of 48 hours. This explains why the quick-setting commercial varieties can usually be put into service within 24 hours; and why, during construction, they set up rapidly enough so that the bricklayer need not limit the number of courses laid in a given time. Because of the danger of squeezing the cement from the joints, work with ordinary silicate cement should not be laid up for more than 4 to 12 courses per day, depending upon the weight of the shapes being cemented.

Sodium silicate is also the binder in many refractory cements, particularly those requiring acid resistance. For such cements, the filler material is commonly raw or burned fireclay, ground firebrick, chromite, silica, mica, asbestos, graphite, soapstone, silicon carbide or mixtures of two or more of these. Such cements are useful to a temperature roughly corresponding to the average of the softening points of the several ingredients. Maximum refractory character, therefore, is developed by silicate of 1:3.86 ratio which has a melting point of 2,000 deg. F. A good furnace cement for laying up brick or lining furnaces is described as:

- 77 lb. silicon carbide firesand, or chromite ore
- 23 lb. raw fireclay
- 9 lb. silicate solution of 1:2.44 soda-silica ratio
- 8 lb. water

Another formula is:

- 94 lb. silicon carbide firesand, or chromite ore
- 6 lb. raw fireclay
- 11 lb. silicate solution of 1:2.44 soda-silica ratio
- 11 lb. water

Organic Binder Cements and Lutes

Asphalt, pitches, gilsonite, blown petroleum residues, linseed oil and rubber are principal ingredients in a great many water-, acid- and alkali-proof compounds, most of which are luting rather than cementing materials. A few of these compounds are proof against hydrocarbons, but the group, in general, is not. In most cases a filler, such as one of those mentioned in conjunction with silicate cements, is incorporated with the organic binder, although satisfactory joints in bell and spigot pipes are often made using a fairly high melting asphalt which is poured into the bell on top of a calking of asbestos rope. Asphalt joints remain

fairly elastic and are easily removed by heating with a blow torch. They are unsuited to use in most organic solvents and with oxidizing agents such as strong nitric acid.

Many good organic lutes can be prepared from blown asphalt to which is added silex, asbestos and similar fillers. A heavy naphtha is suitable as a thinner, if the material is to be applied as a waterproof coating. Boiled linseed oil thickened to a putty with inert fillers makes satisfactory acidproof joints. Sometimes boiled linseed oil is combined with some melted bituminous material and an inert filler.

A number of specific formulas are given below: A black putty composed of equal parts of china clay, boiled linseed oil and melted pitch is suitable for most acids. A red putty of 1 part of boiled linseed oil, combined with 5 parts of red iron oxide (or a mixture of iron oxide and barium sulphate) is recommended for acids and acid gases to temperatures of 500 deg. F. Another of red and white lead in boiled linseed oil is suitable for steam and water. A putty of boiled linseed oil and fireclay or other inert filler is said to withstand most acids, including nitric. As an example, 20-30 lb. of silex and 10 lb. of asbestos in 6 qt. of boiled linseed oil may be mentioned. Another nitric-proof putty contains 8 lb. of red lead, 80 lb. of litharge, 10 lb. of flock asbestos and 6 qt. of boiled linseed oil.

Rubber is used as an ingredient in some of these lutes. In one, 1 part by weight of fresh, unvulcanized rubber (put into solution in carbon bisulphide) is combined hot with 1 part of boiled linseed oil. Or by using four times as much oil, 6 parts of inert filler can be added. Such a lute remains flexible and is suitable for hydrochloric acid. Another lute contains equal parts of raw linseed oil and masticated rubber, heated together and made into a stiff putty with asbestos fiber. This mixture is said to be suitable for glass pipe. Rubber-linseed lutes are flammable, however, and are avoided on that account by many engineers.

Miscellaneous Lutes and Cements

Litharge and glycerine mixtures, to which is sometimes added red lead, are used to a large extent for making pipe threads tight, as well as for the setting of tiles for sulphite digester linings. Litharge-glycerine cements are suitable for hydrocarbons, most mineral acids and ammonia, but are not recommended for caustic alkalis, sulphuric or acetic acids. One mixture consists of 50 g. of litharge to which is added 60 cc. of dilute glycerine (5 parts of glycerine and 2 of water). This is said to set in 10 minutes and to be completely hard in

3 hours. Another contains 9 parts by volume of glycerine plus 1 part of water, made into a stiff putty with 9 parts by weight of litharge and 1 of red lead. This sets in one day. Instead of litharge, red lead is sometimes combined with glycerine, making a good permanent joint that is resistant to acids and acid fumes, and is suitable for cast iron.

Glue is used in certain lutes as, for example, a mixture of 2 parts of dry glue dissolved in 7 parts of hot water and mixed with 1 part of glycerine. This preparation is proof against oil and oil vapors. Molasses and clay or flour made into a putty is also used for oil vapor resistance.

Sulphur-Base Cements

Sulphur, melted and mixed with various inert fillers, usually sand, portland cement, or powdered stone, makes a satisfactory pouring cement both for setting brick and for luting bell and spigot pipe. A mixture of half sulphur, half sand, has a tensile strength higher than the best acid-set silicate cement and is completely resistant to most acids at temperatures to about 220 deg. F. Such cements are sometimes cast into forms, in building small tanks or electrolytic cells. A melted mixture of 1 part sulphur, 1 of rosin and 2 of fireclay has been recommended for hydrochloric acid vapors. Pitch and sulphur are sometimes melted together for acid resistance.

The so-called rust joints, or iron cements, consist of iron powder, combined with an oxidizing agent or some material electronegative to iron, and an electrolyte. Galvanic action is responsible for the formation of iron oxide which sets hard and swells at the same time. Such cements are heat- and alkali- but not acid-resistant. A typical combination contains 40 parts of oil-free iron filings, 10 parts of MnO₂, or sulphur, 1 part of sal ammoniac, 20-40 parts of portland cement and sufficient water to make a paste. This mixture is understood to be very similar to a well-known iron cement now on the market. Another mixture contains 100 parts of filings, 2 of sulphur and 1 of sal ammoniac.

Synthetic Resin Cements

Recently several cements employing a synthetic resin binder of the phenol-formaldehyde type have been put on the market in the United States after considerable use in Germany. Such cements are a good deal stronger than other acidproof cements and have the advantage, over silicate cements, of being completely impervious to liquids and gases. They are unsuitable for oxidizing agents, strong bases and some

organic solvents. As they are more expensive than silicate cements, they are generally used only for service where the silicate compounds are unsuitable.

Cements for Specific Uses

In the following section it is the intention to correlate briefly some of the information that has gone before, listing cementing and luting materials that may be used for specific purposes. This correlation is by no means exhaustive, but is intended merely to suggest certain of the materials that are useful in particular cases.

Acids (Strong)—Any sodium silicate cement (except for HF); putties of inert materials with linseed oil, asphalt (except for nitric) and rubber; sulphur cements; litharge and glycerine (except sulphuric and acetic acids); red lead and glycerine.

Acids (Weak)—Same as for strong acids except that only those sodium silicate cements which contain chemical setting agents are reliable in this use.

Ammonia—Litharge and glycerine, sodium silicate cements.

Gas—White lead in linseed oil; plaster of paris and glue (waterproofed with bituminous coating).

Halogens—Same as for strong acids.

Hydrocarbons—Red or white lead in linseed oil; shellac; nitrocellulose cements; portland cement; litharge and glycerine; molasses and filler; linseed oil and filler; silicate cements; glue and glycerine; sulphur cements.

High Temperatures—Fireclay; silicate cements; rust joints.

Steam—Red or white lead in linseed oil; litharge and glycerine; rust joints; graphite in oil (pipe joints).

Sulphite Digesters—Silicate cements; litharge and glycerine.

Water and Dilute Solutions—Chemically set sodium silicate cements; bituminous materials; litharge and glycerine; sulphur cements.

Use of Cements

Whether or not a particular cement will be satisfactory in a given case as often depends on the way it is used as on its intrinsic suitability. Four factors must be watched in the average cement job, including (1) preparation of the surface to which the cement is to be applied; (2) choice and mixing of the cement; (3) application of the cement; and (4) after-treatment of the cement.

Surface Preparation—Some cements will not adhere satisfactorily unless the surface is scraped or roughened. This is not true of the silicate cements, which require only that the surface be clean and neutral. An alkaline surface such as portland cement that is to be treated with silicate cement should be washed

with 3 per cent hydrochloric acid and then water. An acid surface, such as acid-saturated brickwork requiring repair, should be neutralized with 5 per cent caustic soda. When steel tanks are to be lined with acidproof brickwork set in silicate cement, no treatment of the steel is needed, but concrete and brick tanks require first an impervious bituminous coating because of the pervious character of the cement itself. The same is true of acidproof flooring. Sometimes the surfaces in contact with the cement are best prepared by painting with neat portland cement, silicate solution, shellac or glue.

In general no preparation of the surface is required in luting bell and spigot joints, except that, particularly with the more fluid lutes, asbestos rope should

Effect of Temperature on Working and Hardening Time of a Chemical-Setting Silicate Cement

(Pen-Chlor, Inc.)		
Temperature, Deg. F.	Working Time, Hours	Hardening Time, Days
40	5	7
50	1.5	5
60	$\frac{1}{2}$	4
70	$\frac{1}{4}$	3
80	$\frac{1}{8}$	2

be used to calk the bottom of the joint. This assists in holding the material in the joint until it has set and in retaining it if the temperature in service should go to a point which would cause the lute to flow.

Expansion Characteristics Important

Choice and Mixing of Cements—Except for comparatively fragile work, the cement chosen for a given job is preferably one that expands slightly as it sets, such as the iron cements and those containing linseed oil. For stoneware, however, expansion should be avoided. In any event, where equipment is subject to temperature change, it is desirable to use a cement having a coefficient of expansion as nearly equal to that of the equipment as possible.

Many cements, however, tend to shrink on setting, for which reason it is desirable to avoid too great fluidity in the mixing. As a general rule, the more fluid a cement is made, the greater the shrinkage will be.

In the case of proprietary cements, it goes without saying that manufacturers' directions for mixing must be followed faithfully. In general, different cements should not be mixed together as the result is almost certain to be unsatisfactory.

A point that requires careful watching in using quick-setting cements is the quantity mixed at one time. Since these materials become unworkable very quickly, and cannot be reworked, experiment is necessary to determine

the maximum quantity to be prepared at one time. The influence of working temperature on a typical cement of this type is shown in the accompanying tabulation.

Thin Joints Usually Necessary

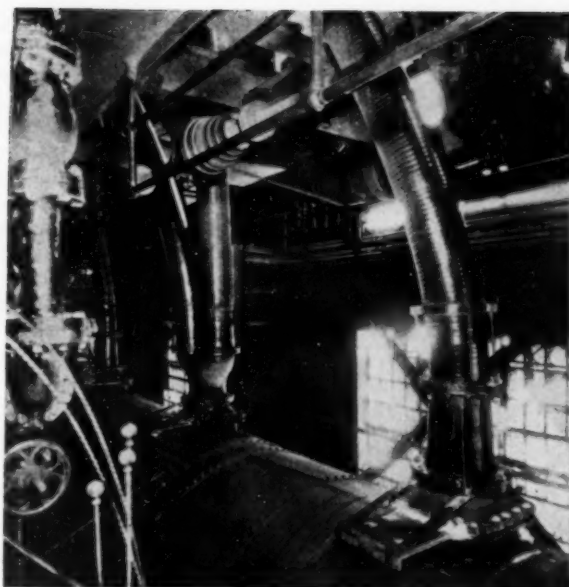
Application of Cements—As a general rule, hard-setting cements, such as the silicate mixtures, should be used with the thinnest possible joints, not over $\frac{1}{8}$ in. and preferably $\frac{1}{16}$ in. Brick should be "buttered" and tapped into place. In the case of slow-setting cements, the number of bricks laid per day must be limited so that the weight of the work will not squeeze the unhardened cement from the joints in the lower courses. Cements and lutes that are softened or made fluid by heating must not be overheated. This is particularly true of sulphur cements which increase in viscosity with rise in temperature above the point of greatest fluidity. Furthermore, many of these heat-softening cements and lutes are flammable at higher temperatures.

After-Treatment—Slow-setting silicate cements require an acid wash after the air set is fully attained. In cooler weather, artificial heating may be necessary to hasten the air set. The acid wash is generally accomplished by brushing or spraying the exposed joint surfaces with sulphuric or hydrochloric acid. Quick-setting silicate cements usually require no acid wash, although it is sometimes desirable to neutralize the alkaline layer which forms on the surface. Any silicate cement may be hardened by applying a solution of a calcium salt, such as the chloride, if it is desired to avoid in use the solution of the sodium salt set free by the formation of silicic acid.

Most cements, other than the silicate mixtures, require no after treatment, except that those that are not thoroughly waterproof should be given a bituminous coating if exposed to the weather. All cements, however, should be permitted to attain the greater part of their set before being put into service.

Acknowledgments

Many sources have been consulted in compiling the data for this article. Chief among them are the papers of S. S. Sadler, presented before the American Institute of Chemical Engineers in 1916 and 1927; a noteworthy compilation of cements and putties given in *The Industrial Chemist* (London), November, 1933; and various of the writings of James G. Vail, of the Philadelphia Quartz Co. General acknowledgment is also made for the valuable assistance rendered by a large number of cement manufacturers.



Manner of attachment and support and how it is possible to get around beam or shafting obstruction with rubber piping

RUBBER EQUIPMENT for CHEMICAL PLANTS

By C. A. RUSS

*United States Rubber Co.
New York, N. Y.*

RUBBER LININGS and protective coverings of proven types are recognized as one of the standardized materials for protection against corrosion. More than a decade ago, when vulcanized rubber linings securely bonded to metal or wood were first perfected, the limit of application range was considered as being storage or transportation equipment operated at normal temperatures. During the past five years the demand has increased for new and unique types of rubber linings that can be safely applied in process equipment and for a wider range of uses.

As regards the rubber lining itself, it has been proved that no one type is applicable for all conditions if maximum benefit is to be expected. To adequately cover the field for which rubber is safe and economical, the manufacturer of U. S. Permobond recommends Khemline, Kleerline, Duroline, Tuffline or Gumline, each of which is adapted to certain operating conditions. These

types range in characteristics from a soft, pure gum, non-contaminating lining to the flexible superquality of hard rubber for higher temperatures and certain chemicals which have an excessive corrosive effect on the softer linings.

Full advantage of the improved types of rubber tank linings can be best obtained by close cooperative effect between the chemical engineer and the rubber engineer. A report of operating conditions with reasonably complete details should be carefully analyzed before a forecast as to ultimate economy can be made.

The use of rubber-lined acid hose is not new to the chemical industry. The rubber lining of this conducting medium has been proved to be the most practical for handling certain chemicals. Its outstanding limitation is the necessity for the attachment of metal couplings which, though even made of acid resisting alloys, tend to corrode and often-times require replacement before the

hose itself has outlived its usefulness. U. S. Pilot pipe is furnished with a continuous lining, which extends over the built-in flanges, to the point the pipe and the flanges are one integral element. The outside of the pipe and flanges is covered with an acidproof type of rubber, which prevents damage to the pipe due to spillage or overflow. The flexible characteristics of this pipe permit quick attachment and adaptability to curvature, thereby eliminating the usual number of ells and other fittings.

A multiplicity of chemicals can be safely carried in U. S. Pilot pipe. As is generally known, rubber has outstanding corrosive resistance to most alkali solutions and many acids, including hydrochloric at any strength and sulphuric of less than 50 per cent concentration.

A troublesome problem at times to the chemical engineer is the proper choice of pipe that will conduct a destructive chemical in which 10 or 15 per cent of solid is in suspension. The combined corrosive effect of the chemical plus the abrasion effect of the solids, makes for a decidedly limited life obtained from ordinary pipe. But this special pipe is especially adapted for this service. In addition, it has been used successfully for conveying powdered coal and coke, cement, lime and other solids, carried either by air pressure or by gravity flow.

▼ ▼ ▼ CENTRIFUGES

The bowls of Super Centrifuges used to recover platinum from the spent sulphuric acid mass are made of Monel metal to minimize the galvanic couple formed by the metallic deposit in the bowl and bowl shell. For the same reason they are used to recover silver halides from waste photographic emulsion.

Since the introduction of Monel metal bowl, pharmaceutical and chemical manufacturers have become important users of centrifuges. Such interesting developments as these have occurred: the removal of sex hormones from fetal fluid, the production of serums and antitoxins, manufacture of acidophilus bacillae blocks, acid and alcohol solutions and removal of pulp from tomato soup.

By providing a material of the required physical properties and added corrosive and erosive resistance to the bowl, Monel metal has greatly extended the scope of the Sharples Super Centrifuge.



Laminated phenolic resin bubble caps after two years in service

PHENOLIC BUBBLE CAPS IN RECOVERY PLANT

By G. W. CLARK

*Chemical Engineer, Micarta Division
Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.*

AS A RESULT of several years of testing in an operating solvent recovery process, the use of phenolic laminated bubble caps in scrubbers and rectification columns has been found to be a means of securing longer life and freedom from corrosion. Although first cost is higher than that of iron, there is real economy in the elimination of solvent loss from shut downs, or reduced capacity, and the expensive removal of iron caps for cleaning and replacement. In comparison with copper, Micarta caps have a favorable first cost and an equal resistance to the action of many boiling liquids such as water, alcohols, ketones and esters.

The recovery of alcohol and furfural from the treating processes at the Micarta plant of the Westinghouse Electric & Manufacturing Co. is accomplished by passing the air-vapor mixture successively through a packed water spray cooling tower, blowers and bubble cap type scrubbers. From these a mixture of water, alcohol, furfural and cresol is pumped to storage for later rectification through exhausting furfural and alcohol columns.

The action of the liquid mixtures on iron bubble caps caused clogging of the slots with rust, resulting in increased back pressure, reduced air capacity and expensive and laborious removal and cleaning of the caps. It was decided to try out phenolic laminated as a substitute for iron. Accordingly, the decks in the lower half of each scrubber where the worst corrosion had taken place were equipped with caps made of phenolic laminated in the Micarta plant. Laminated caps were also installed in the exhausting column to obtain a comparison with the copper caps in use there in contact with boiling liquids.

After new iron caps had been in use for 10 mo., the fans of the solvent recovery system were found to deliver only one-half of their former air capacity. Investigation showed that the loss of capacity was due to rust blocking the $\frac{1}{4}$ -in. wide slots in the iron bubble caps in the scrubbers. On many caps, the slots were entirely closed by rust, and there were practically none with slots more than $\frac{1}{16}$ of an inch wide.

Scraping the rust off by hand after removing the caps from the scrubbers

cost about 15c. per set (one bubble cap and one riser pipe). Shot blasting cost 5c. per set. Cleaning with acid and scraping the last of the rust by hand cost 5c. per set for labor and 8c. per set for materials. The labor cost of removing caps from a scrubber and replacing after cleaning was 6c. per set. Inasmuch as there are upwards of 1,000 sets in each scrubber, it is obvious that a real saving is possible by using a non-rusting material for the caps. In spite of the higher cost, cleaning with acid (7 per cent sulphuric acid with an inhibitor added to keep the acid from attacking the iron) will prove more economical in the long run because the caps will last several years more (less loss of metal) than they will if they are shot blasted away every 6 to 12 mo. The following table gives a comparison of caps cleaned by the two methods:

	After Shot Blasted	After Acid Cleaned
Average weight.....	3 lb. 3 oz.	3 lb. 4½ oz.
Width of slots.....	$\frac{1}{4}$ to $\frac{3}{8}$ in.	$\frac{1}{4}$ in.
Thickness of metal.....	$\frac{11}{16}$ to $\frac{13}{16}$ in.	$\frac{11}{16}$ in.
Appearance.....	Fitted	Smooth

Two decks of one scrubber were examined after 11 mo. of usage of cleaned and lacquered iron caps. One was equipped with caps that had been cleaned by shot blasting. The caps on the other deck had been cleaned with acid. Both types of cleaned caps had been dipped twice in Bakelite varnish and baked for several hours. The closing of the slots in the caps by rust amounted to about 20 per cent on both decks. No superiority as regards rusting of one type of cleaning over the other was apparent. On both decks the space between the lower edge of the caps and the deck was about half closed by the building up of rust on the deck.

After four months of additional usage, examination was again made of the iron caps in the scrubbers. The slots were found to be one-half to three-quarters closed and decks littered with rust. Removal of the caps and a thorough cleaning of decks and caps were required.

During 12 mo. of this same period, plates 6 in. x 6 in. x $\frac{1}{4}$ in. having one or more holes drilled in them were placed on the deck of a scrubber and subjected to the same conditions as the bubble caps. These plates were of molded composition and laminated from several materials. From these tests the most suitable material for making a Micarta bubble cap was selected.

At the time of the second cleaning of the iron bubble caps, several decks of each scrubber were equipped with phenolic laminated bubble caps, using with them the iron risers and iron decks previously in service. These caps were placed on the lower decks where the conditions are most severe (concentration of alcohol, furfural, and cresols

being strongest and temperature highest). Examination of these caps eight months later showed them to be unchanged except for a fine deposit of rust which was readily wiped off.

Examination was last made of the Micarta bubble caps in the bottom deck of one scrubber and the bottom two decks of the other scrubber, as well as of the lacquered iron caps in the fifth and sixth decks of this second scrubber after 22 mo. of continuous service. The Micarta caps were found in excellent condition, showing only a slight film of deposited rust which was easily wiped off and the space between the deck and

the bottom of the caps was still 75 per cent free of rust. The iron caps were heavily rusted, although their location higher up in the scrubber had prevented serious clogging.

The still was cleaned in September, 1932, and three molded bubble caps were placed in the exhausting column at the third, sixth and tenth decks counting from the bottom. This column exhausts water at the bottom. It delivers cresylic acid type liquids, furfural, and alcohol mixture at about the half way point and alcohol and water at the top. The tendency to corrode is greatest at the center of the column. Inspection of

these caps after 6, 14 and 21 mo. showed them to be in very good condition at the third and tenth decks but noticeably corroded at the sixth deck.

Micarta caps are therefore recommended for service in boiling water or alcohol but not in boiling furfural or cresol concentrates. Use of these caps with strong alkalis such as lye and potash solutions and with oxidizing acids such as nitric and chromic acids should be avoided. Favorable applications include boiling esters, alcohols, paraffins, ketones, cold weak mineral acids and weakly alkaline liquids which are often encountered.



NEW TYPES of PEBBLE MILL LININGS for INK PRODUCTION

By ROBERT RULLMAN

*Patterson Foundry & Machine Co.
East Liverpool, Ohio*

ROTOGRAVURE and photogravure are the names now applied to that process of Intaglio or sub-surface printing originally known as "gravure" printing. It was developed in 1873 by a Bohemian named Karl Klec and was used by him in the making of fine art prints. Dr. Edward Mertens of Freiburg, Germany first saw the adaptability of this process to newspaper printing and it was he who constructed and perfected the first presses used in newspaper gravure printing.

Rotogravure inks, commonly mentioned as roto inks, are usually of the varnish type. The water vehicle inks are still considered in the process of evolution. These varnish inks are composed primarily of two component parts—the pigment and the vehicle. Liquid vehicles are made up of various combinations with varying percentages of solvents and gums. Solvents are usually the petroleum naphthas, xylol, toluol and benzol of varying specifications, depending, of course, upon results desired, whereas in some instances percentages of water are emulsified with these vehicles. With different manufacturers the method of processing the vehicle varies somewhat but, in general, all manufacturers can furnish inks of varying color values and drying speeds while the finishes vary from high gloss to complete mat.

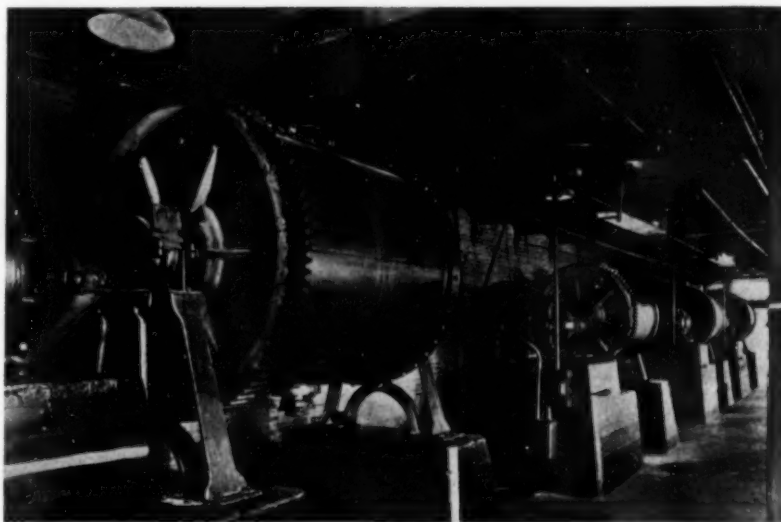
Gums used are for the most part of the copal type natural fossil resin, synthetic esters, treated resins and in the case of brown, black and green inks considerable use is made of gilsonite, both on account of its economy and the much desired duotone effect resulting from its use.

Hue, strength, physical characteristics and oil-taking qualities are the impor-

tant requisites for the pigments suitable for use in the manufacture of roto ink. The ideal pigment should have all of the foregoing qualities and, in addition, it must be free from crystalline structure and must be finely divided and capable of being easily wetted or dispersed.

The finished roto ink must be absolutely free from abrasives of any kind for even the slightest abrasion will cause undue wear of both the cylinder and the "doctor knife," lessening the life of both and greatly increasing maintenance cost.

The earlier inks were supplied to the



Pebble mills for producing rotogravure inks. Synthetic silicate and special chrome-manganese steel linings offer many advantages

printers in an extremely heavy paste form and it became the arduous task of the printer to thin it out to proper consistency before filling the fountains of his rotogravure presses and, due to the evaporation of the solvents, the uniformity of this product was never maintained. Heavy paste mixers were originally used to premix the pigments and the vehicles and this was then ground in iron pot mills and on buhrstone and roller mills as these constituted the only machinery available at that time for the production of thin ink, but as the use of roto ink became greater and as the field broadened a less costly and better method of production became necessary and manufacturers sought a method whereby a smoother and more uniform product could be manufactured and one which would permit of the ink being furnished to the printer in the proper consistency for his use.

The pebble mill, first because all operations could be confined to the one machine and, second, because all operation could be performed in a closed container, was selected as being best adapted to the needs of the ink maker and its universal adoption has resulted. Both pigments and vehicle are placed in these mills which are rotated for a given number of hours, no attention being required during the grinding operation, and the finished product is discharged from the mill in the proper consistency for use. The rolling and tumbling action of the balls grinds the product to the desired fineness and the grinding surface presented by the many spheres in the mill is far greater than that of any other type of grinder.

The first pebble mills used in the production of roto ink were lined with French buhrstone, and pebbles imported from Denmark and from France were used as the grinding media. Some five years ago a synthetic silicate known as Porox replaced these buhrstone linings and white balls made of the same material replaced the pebbles, resulting in a smoother product and a better contact or tooth between the grinding mediums. The presence of grit was eliminated from the product and a greater volume was possible because of the difference in the thickness of the linings, the old buhrstone lining being approximately 3 in. thick and the newer Porox lining 2 in. Buhrstone linings are rough quarried blocks, necessitating a wide cement joint between the blocks while the Porox blocks, being made in dies, may be laid with small joints and, being perfectly smooth, there are, of course, no protrusions such as occur with buhrstone.

Within the past few years a newer type of pebble mill has made its appearance. This new mill does not have

a lining but both the heads and shell are made from an alloy steel containing a high percentage of chrome-manganese and some nickel. The grinding medium is still balls made of chrome-manganese steel. These balls are usually of small diameter and consequently the weight per cubic foot is much greater than is possible with larger balls, and inasmuch as the chrome-manganese steel balls weigh nearly three times as much as either the Porox balls or the flint pebbles the pressure during the grinding operation is three times as great and, while more power is required, the grinding time is greatly reduced, more than compensating for the additional power consumption.

Generally speaking, the newer type of unlined mills, built of chrome-manganese steel and equipped with chrome-manganese balls, is used for the production of such colors as brown, black, green, blue and some of the reds while the Porox lined mills equipped with Porox grinding balls are used for the delicate pastel shades such as the yellows, the lakes and, of course, for white although some manufacturers are using the unlined mills for some of the lighter shades as well.

The grinding time and viscosities vary according to color and size of batches produced. With different manufacturers it is customary to vary the time and viscosity depending upon the vehicles and pigments necessary for the production of the different inks. The finished product may, if so desired, be discharged directly into containers ready for shipment.

The Roto Ink Corp., Chicago, manufactures some of its pigments in the conventional mixing apparatus, filter presses and dryers. The complement of mills illustrated, and which are of varying sizes, gives this company flexibility.

Summing up the advantages of this type of plant, we have first, low cost of production because one machine only is used in the entire process. There are no premixers and no thinning mixers, consequently there is a saving in floor space, power and labor. The plant may be kept clean as there is no transfer of the paste or semi-paste, the raw materials being placed in the mill and the finished product being withdrawn directly from it. There is no loss of solvents and inasmuch as each batch is ground exactly the same number of revolutions each batch must be identical with previous ones produced in the same machine. By the use of this closed container type of grinder all obnoxious and poisonous odors are confined to the equipment and cannot escape into the grinding room. This means better working conditions, steadier man power, lower health insurance and less labor turnover. Fire hazard is greatly minimized and insurance premiums reduced accordingly. Inasmuch as no attention is required during the grinding period, it is the custom in many plants to load the mills before quitting time in the evening, allow them to run all night with only infrequent attention from the night watchman and then to discharge the finished product in the morning.



GLASS-LINED STEEL DEVELOPMENTS

AN ENTIRELY NEW departure during the last year has been the development of a glass-lined acid-resisting valve by the Pfaudler Co., which already has had extensive use in the chemical and food industries. The principal of the valve is the compressing of a tough, resilient diaphragm between two metal surfaces. The valve body is entirely lined with acid-resisting enamel. The diaphragm is made of rubber, Thiokol, or Duprene, depending on service. Another development in the line of glass-lined steel equipment is the small scale autoclave. It is built for a pressure of 1,000 lb. per sq.in.

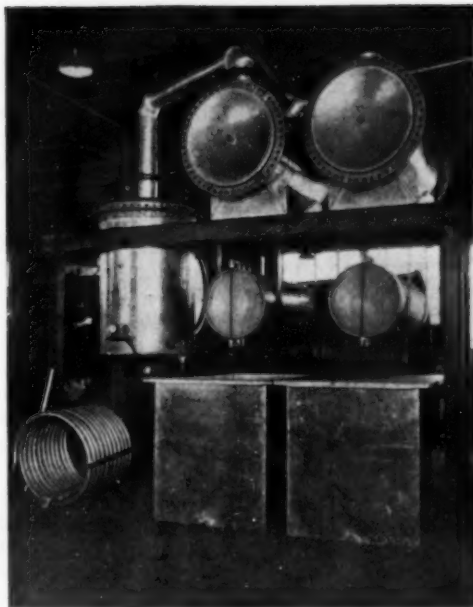
This same type of equipment has become more extensively used in dyeing,

bleaching, and finishing operations because it is chemically resistant, non-absorptive and easy to clean. Due to its high resistance to acid, glass enamel is particularly well adaptable for the dyeing of wool, where the bath is usually on the acid side. It is now possible to obtain glass-lined steel piece dye kettles of the conventional rectangular sloping-back design, including accessories such as guides and whip-rolls of the same material.

Other uses for glass-lined steel are found in dye storage and mixing tanks, portable tanks for handling print pastes, mixers for the preparation of sizings, and storage tanks for materials such as red oil and olive oil.

ARC WELDED ALUMINUM

Distillation equipment
constructed entirely of
arc welded aluminum



CONSTRUCTION of arc welded aluminum distillation equipment for a new chemical process has been completed by the Thornton Co., Cleveland, Ohio. The equipment is believed to be the first of the kind ever built and is one of the most involved welded aluminum projects yet reported.

The process requires a still connecting with two condensers below which are two drip tanks and two receiving tanks. This still is built of $\frac{3}{8}$ in. aluminum welded with one longitudinal

seam, the edges of the plate being vee'd out preparatory to welding. The bottom of the still is a dished plate and the top is bolted on by means of angles which are lap-welded to the body of the still and to the top. Forming of these heavy angles was a difficult operation. Inside the still is a 3 in. diameter coil of extra strong aluminum pipe, 15 coils high. The still operates under a 29 in. vacuum.

The two condensers are exceptionally interesting. The shells and heads are

of $\frac{3}{8}$ in. plate, the bulkheads of $\frac{1}{2}$ in. plate; 140 tubes are used in each condenser. No difficulties were experienced in the welding of the condensers despite the heavy plate used. Welds were tested under 100 lb. pressure with no flaws being detected in any of the welds. The condensers which operate at 75 lb. pressure are equipped with supports of welded heavy plate.

Eight inch piping, fabricated complete by arc welding from aluminum sheets, connects the condensers and the still. More than \$50 was saved on this piping alone over the cost of cast fittings.

The two rectangular and two cylindrical receiving tanks below the condensers were also arc welded in their entirety, including the fittings. All welding was done by the shielded arc process using Aluminweld electrodes and arc welding generators manufactured by Lincoln Electric Co. The electrode used was selected on the basis of maximum penetration, density, and ease of handling. Sheets used were 3S aluminum throughout.

Many unusual problems arose as this distillation plant was the first of its kind to be built and there were no precedents to follow. Arc welded construction was decided upon due to its simplicity, speed, and efficient distribution of metal. According to the manufacturer, any other method of construction would necessitate the use of exceedingly expensive castings which would also increase the weight of the equipment and would require much longer time to complete.

SILVER EQUIPMENT in CHEMICAL PLANTS

By IRL C. SCHOONOVER

*Bureau of Standards, Div. of Metallurgy
Washington, D. C.*

SILVER, one of the metals earliest known to man, has always been utilized mainly as a decorative metal and for coinage. In recent times the photo-sensitive properties of silver salts have been the basis of another major field of application, photography. A few years ago various circumstances combined to lessen the previously existing demand for silver and the price of the metal decreased considerably. Undoubtedly, this situation did much to bring about the consideration of industrial applications of silver and its alloys.

Early in 1934 a representative group of American silver producers established, at the Bureau of Standards, a research associateship to make a survey of the properties of silver and its alloys, particularly in regard to existing and potential engineering or other industrial uses. In the following will be presented some of the interesting applications and

possibilities of silver in chemical equipment which have already come to the attention of those engaged in this work. Some of the information has been obtained from 20 representative chemical plants which the author was privileged to visit. Correspondence with various people both in this country and abroad has also contributed a number of instances of the use of silver chemical equipment. The information from both sources has to a considerable extent been confirmed by scattered references throughout the literature.

The existing and potential uses of silver have been considered only on the

basis of the corrosion resistance of the metal and its convenience in other respects as a material of construction for special equipment. The bactericidal action of the metal as well as of any other possible effects of the presence of small quantities of silver in food and chemical products are outside the scope of this discussion.

Many of the characteristic properties of silver are well known as, for example, its extreme ductility and its high thermal and electrical conductivity. It is a relatively soft metal even at room temperatures and does not, therefore, possess much strength at elevated tempera-

tures. However, the high-temperature strength desirable for certain engineering applications can probably be secured by using silver-lined equipment constructed of duplex material, a suitable high-temperature alloy being used as supporting material.

Probably the best known of the chemical properties of silver are the resistance to formation of oxide scale at elevated temperatures, the ease of formation of halides, the relative insolubility of the halides, and the extreme sensitivity to sulphur. The first two of these characteristic chemical properties are in large part responsible for its use as a corrosion resistant material.

Little information is available concerning the solubility and the tenacity of the protective coating of silver chloride which forms on silver when the metal is in contact with hydrochloric acid or chlorine. Small installations of silver equipment have been used successfully for processes in which dilute hydrochloric acid is one of the products. The extent to which silver may be used to advantage in the hydrochloric acid plant is not certain. The handling of both wet and dry chlorine in silver is fairly common practice in filtration plants employing chlorination.

Conflicting opinions have been expressed as to the attack of silver by hydrofluoric acid. It is reported that pure hydrofluoric acid, free from fluosilicic acid, in any concentrations, hot or cold, does not attack silver. The proposed use of silver-lined containers for handling this acid appears promising.

Iodine vapors attack silver and this attack is presumably not limited to the formation of a protective coating, as a silver lining in contact with wet iodine has been observed to corrode badly. No examples of industrial use of silver in the presence of bromine, hydrobromic acid, or hydriodic acid are known to the author.

While it appears that fine, or pure, silver has only a limited application with the halogens and their acids certain alloys high in silver may be useful in this field. One alloy in particular, the composition and physical properties of which has very recently been described in the literature (*Chem. and Ind.*, Vol. 52, 1933, p. 687) as being extremely resistant to attack by hydrochloric acid, may aid in solving the corrosion problems in this field.

Sodium and potassium hydroxide fusions have long been carried out in silver crucibles. Silver evaporating pans, molds, and ladles are used for the preparation of the best grades of sodium and potassium chlorides and hydroxides. An interesting application of silver in this field is the use of pure silver plugs for alkali burettes. Silver is reported to be completely resistant to ammonia,

in the absence of hydrochloric fumes.

Many organic acids do not attack silver and it is in this field of the chemical manufacturing industry that a large proportion of the silver equipment actually in use at the present time is to be found. In the case of acetic acid which manifests its greatest corrosive action at the point where the hot vapors condense during distillation, silver condensers, stills, vats, and taps are successfully and extensively used. Some of this equipment is very large and may be either constructed of pure silver or lined with silver. A part of the success of silver in this field can be attributed to the absence of colored substances in many organic products, even if some contamination by silver does occur. This is considered important in the manufacture of white vinegar for pickling purposes, where even very slight discoloration is objectionable. Silver-lined vats have been used for handling acetic anhydride. In the preparation of phenol, especially the better grades suitable for pharmaceutical purposes, silver stills, condensers, and taps are used. Silver-lined steel barrels have been used to transport glycerine for pharmaceutical purposes. Use of silver for equipment for manufacturing phthalic, benzoic, and lactic acids has also been proposed.

Phosphoric acid attacks silver slightly but phosphates are said to have no effect upon it. Steam-jacketed silver kettles have given many years of satisfactory service in the preparation of the sodium salts of phosphoric acid. Sulphuric acid, in any concentration, attacks silver to some extent. There is, however, some evidence that lead containing small quantities of silver and cadmium is more resistant to this acid than the chemical lead ordinarily used (*Zshrift f. anorg. u. allg. Chemie*, Vol. 212, 1933, p. 326).

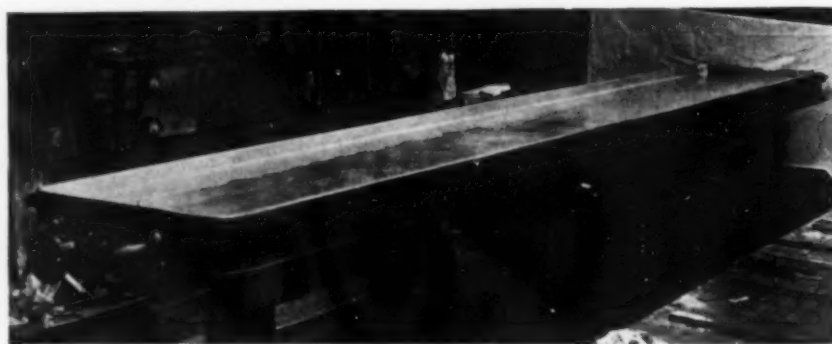
In the production of foodstuffs, jams, jellies and beverages silver appears to have found wider usage abroad than in this country. Silver pipe lines, siphons, taps, nozzles, and containers have long been used for the handling and dispensing of beverages. Pure silver and sil-

ver-lined stills, condensers, and pipe lines have been used in the preparation of fruit juices and extracts. Jams, jellies and allied products are being made in pure silver or silver-lined autoclaves, evaporating pans, vacuum stills and similar equipment. In the food industries, silver enjoys a wide usage for one or more of the following reasons: Freedom from any appreciable metallic contamination which might have poisonous effects, cause discoloration, or give the product an undesirable metallic taste; the ease with which the surface of silver containers may be kept free from bacteria, an all-important factor in the preparation of foodstuffs and beverages; the absence of catalytic effects which might cause decomposition of the essential oils which are so necessary for truly characteristic flavors of many products. Silver has not proved to be satisfactory for ordinary cooking utensils due to the presence in many foods of sulphur and sulphur compounds which result in severe tarnishing of the utensils. However, the high thermal conductivity and the resistance of silver to many forms of corrosive attack have made the metal useful for the industrial preparation of acid foods free from sulphur compounds.

Probably the largest quantity of silver in the form of chemical equipment is to be found in the photographic industry. Photographic emulsions must be free from foreign metals and must be handled in tanks which can be kept scrupulously clean, especially free from bacteria. Silver is used for such tanks, evaporating kettles, rolls, and other equipment.

Silver condensers are used in the preparation of certain coal tar products and in the recovery of solvents used in the rayon industry. Silver and silver-lined vacuum pans are used in the tanning industry. Some silver equipment is used in the preparation of aniline dyes and dyestuffs and silver catalysts are used in certain processes. Chains of silver are sometimes used for packing still columns. In the preparation of ordinary inks, equipment involving some silver is often employed.

Silver-plated tank 25 ft. long and 4 ft. wide. Said to be largest silver-plated equipment in this country



GLASS for PILOT PLANT CONSTRUCTION

By DONALD F. OTHMER

*Dept. of Chemical Engineering
Polytechnic Institute
Brooklyn, N. Y.*

THE DEVELOPMENT of processes and equipment for unit chemical manufacturing operations is usually done in two or three intermediary sized units between the test tube and the plant. Work with these "half-way" units presents considerably more difficulty than the operation of the final plant for three reasons:

(1) The operation of the process is as yet unstandardized; and in the earlier stages the optimum or even desirable conditions are usually almost unknown.

(2) Since these stages are transitory and the equipment is often unusable again, it is usually considered not eco-

nomic to incorporate the controls and conveniences of the final plant.

(3) Because of the small size of the first stages, the operation is inclined to be rather unstable or temperamental.

Because of these additional difficulties at this stage, and particularly the small size and economy desired in the smaller units, the choice of construction materials is all important.

For many such miniature plants, and for small production plants for fine chemicals, *Pyrex glass will be found to have many advantages as a material of construction.

In most places where it would be used at all, it is cheaper than any other suitable material. The ease of fabrication requires much less skill than metal working, and the only tool required worthy of note is the oxy-gas lamp. In the usual case a little practice will allow most shapes and connections to be made of standard glass tubing and blown or pressed shapes without calling in outside help. Those parts which cannot be readily made or assembled may be obtained from the Corning Glass Works.

The large number of readily available shapes which may be immediately incorporated allows the ready fabrication without waiting for special parts or designs. As these shapes are made in large quantities of a material which is fundamentally inexpensive compared to most other materials of construction, finished parts may be produced relatively cheaply.

The transparency of finished equipment often allows the control and study of processes which would be impossible with other materials. Pyrex is a much more sturdy material than is usually supposed—even when handled by unskilled labor. The transparency has a psychological effect on workmen which prevents carelessness. Pyrex pipe lines which have been in service ten or more years without breakage are not unknown, and in many cases when its chemical inertness is considered, it will have a longer life than metal units.

*Editor's Note: "Pyrex" is a registered trade mark for a group of boro-silicate glasses and is not descriptive of a particular glass composition.

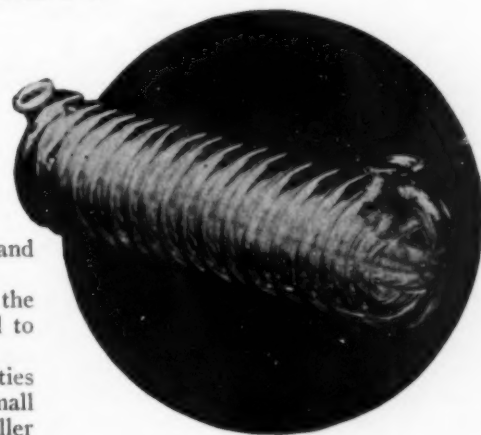


Fig. 1—Glass condenser coils before assembly

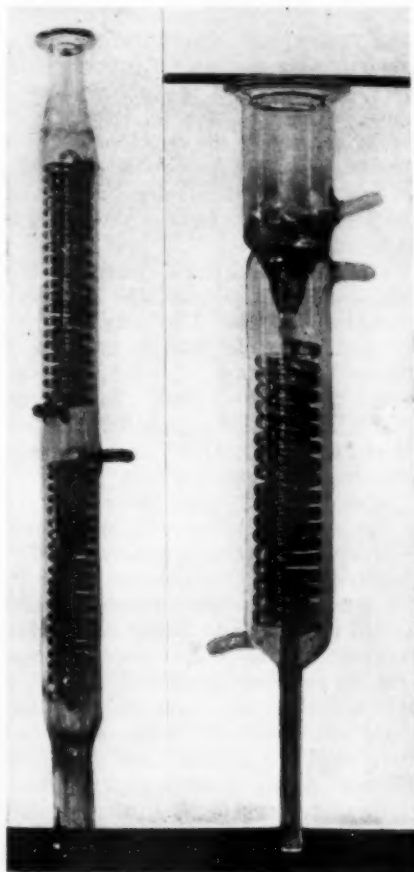
The illustrations show examples of units for pilot plant work. They are merely illustrative of the application of glass to equipment of this nature. Pyrex equipment for several unit processes of chemical engineering has been successfully used.

Condensers have been found to be of considerable usefulness in small plant distillation, extraction, solvent recovery, and evaporation units. In the design of condensers of any size, good engineering practice demands the use of high velocity on the water side, and to disregard if necessary the vapor velocity; since the cooling water film presents most of the resistance to heat transfer. This factor has never been realized by the glass blowers who design and fabricate the usual laboratory condensers; and it is not uncommon to see a small bore coil with vapors inside plugged by condensate and less than half of the condenser area effective. The correct design would, of course, have the liquid flowing through the tube at a comparative high velocity with vapors condensing outside.

Fig. 1 shows the assemblage of two concentric coils with a longitudinal passage of three tubes running back and forth inside. When this assemblage is insealed into a Pyrex tube of only slightly larger diameter, there is small chance of dead spots or hot channels; and the vapors rushing past the maze of cooling coils and tubes are effectively condensed.

Fig. 2 illustrates two of these condensing units. As many as four of these units have been assembled in a single tube; but a less cumbersome system is the joining of single or double units by

Fig. 2—Two unit condenser, 40 in. overall length. Fig. 3—Liquid cooler or heater cooling water (or steam) in shell—liquid in coil



standard Pyrex flanged pipe joints. Units capable of condensing some hundreds of pounds of organic vapors per hour have thus been produced and are being used in industry at the present time.

Badger & Cutting (*Trans. Amer. Inst. of Chem. Eng.* 1926) and Othmer (*Ind. & Eng. Chem.* vol. 21 p. 876 1929) have described small production evaporators of Pyrex glass for use where chemical inertness was the first requisite; and other units of greater capacity and greater simplicity of construction and operation have been built more recently for development work, and also for small production uses. In later units, flexibility for studying different methods of operation and tube arrangement has been accomplished so that by suitable arrangement of the parts several different evaporator types may be reproduced in model form. The vapor-liquid separator or the body of the evaporator is a large flask, 22 liter capacity or larger, with appropriate connections; and the tube and heating arrangement is considerably improved to eliminate the breakage which formerly occurred.

The discharge ends of earlier types are shown in Fig. 4. The insert details a connection in which liquid and vapor are brought into the entrance nozzle from two tubes; and vapor discharged through the annular space of the neck. This arrangement necessitates only a bottom tubulation on the flask. These bodies are constructed of 22 liter flasks; and the connections clamped to the necks of the flask are 3 in. standard flanged Pyrex pipe. In each case, provision is made for separation of vapor and liquid, with the former passing out the top to the condenser.

Othmer (*Ind. & Eng. Chem.* vol. 22, p. 322, 1930) has described units of a size for development work which have since been used in many plants in this and other countries. With some ingenuity in fabrication and care in operation, almost any distillation procedure may be duplicated or studied in miniature units which have on occasion been made to give a considerably greater rectifying efficiency than any plant unit. By combination and simultaneous operation of several—or even more—of these units into a battery of continuous columns, practically any separation or manufacturing operation normally done in rectifying columns in the plant may be duplicated in glass units. They have been successfully built for pressures up to 50 lb. per sq. in., where it was desired to conduct rectifying operations at super-atmospheric pressure pipe stills, all sorts of liquid-vapor contacting devices as well as the related units, counter current liquid-liquid extractors have been devised and used for process development work.

MATERIALS OF CONSTRUCTION FOR PROCESS INDUSTRIES

To reflect standard practice in the selection of materials for equipment construction in 60 process industries, there is included with this number an editorial supplement which is the third in the 1934 series of Chem. & Met. data sheets.

SYNTHETIC RUBBER HOSE

The manufacture of hose for conveying liquids is one of the important branches of the rubber industry. So long as hose is called upon to convey only water or other inert liquids, rubber is an entirely satisfactory material of construction unless the exterior of the hose is constantly exposed to strong sunlight, as in the case of golf-green hose, or to the oils and chemicals which are encountered in many industrial plants. However, when we come to hose for conveying gasoline and oils, the shortcomings of rubber are immediately apparent. This difficulty has been partially circumvented by building gasoline and oil hose with a semi-flexible metal inner tube and by other devices that have increased the weight, decreased the flexibility and increased the resistance to flow through the hose.

Today, hose is being built with a smooth inner tube of a DuPrene compound that resists the action of oils and solvents. It is made in various types for

conveying gasoline, crude oils, fuel oils, lubricating oils, kerosene, and the like.

The rapidly growing use of propane and butane as fuels for bus and truck engines, especially in the Far West, has made it necessary to develop a flexible connection for handling these light petroleum products either as gases or, more commonly, as liquids under pressure. Rubber is unsuitable for this purpose, not only because it is deteriorated by propane and butane, but also because they diffuse rapidly through it with resultant large losses. This problem has been solved by the development of hose in which DuPrene is used in place of rubber. It is unaffected by these hydrocarbons and is only about one-fifth as permeable to them as one made of rubber.

Aside from crude oil and refined petroleum products, many other liquids that attack rubber can be handled without trouble in flexible hose with a DuPrene lining. DuPrene has been successfully used in contact with a variety of synthetic organic liquids, vegetable oils and animal oils. For example, paint-spray hose with an inner tube of a DuPrene compound successfully resists the action of linseed oil and turpentine.

PROTECTIVE COATING

Tornesit is the trade name of a protective coating base prepared by chlorinating rubber. Its stability, fire resistance, inertness to chemical attack, solubility in solvents, ready miscibility with gums and plasticizers make it attractive for the use in process industries plants. The product derives its name from the town, Tornesch, in Germany, where the development work was brought to a successful conclusion. In this country it is being produced by the Hercules Powder Co., Wilmington, Del.

This resin-like raw material is a yellowish-white powder and practically odorless. Its specific gravity is 1.5 and its bulking value is 0.08 gal. per lb. Tornesit can be sprayed, brushed, dipped, or flow-coated. Some high-boiling solvents like high-flash naphtha should be used to avoid lap marks when brushing because Tornesit paints dry even more rapidly than lacquers.

Not only is usual protection afforded steel against rusting but, because of the chemical inertness of chlorinated rubber, this type of paint when properly applied is said to resist 5 to 50 per cent sodium hydroxide, 5 to 95 per cent sulphuric acid, 85 per cent phosphoric acid, dilute hydrochloric acid, bleach solutions, nitric acid, organic acids, and chlorine, sulphur dioxide and ammonia. Tornesit paints have excellent adhesion to concrete and, because of the toughness of the films, they are resistant to abrasive influences.

Fig. 4—Evaporator body or discharge separator made from 22 liter glass flask



CHEM. & MET. 1934-35 DIRECTORY OF MATERIALS

For the Construction of Chemical Engineering Equipment

It is our privilege to present in the following pages what we believe to be the most complete list ever compiled of the corrosion, heat, and abrasion resistant materials used in the construction of chemical engineering equipment.

This is a revision and expansion of the data appearing in the "Modern Metals" and "Modern Materials" section of the September and December, 1932, issues of *Chem. & Met.* For further information regarding chemical and physical properties as well as applications in process industries, the reader is referred to the above sections and to the additional supplement that accompanies this sixth Materials of Construction issue.—EDITORS.

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
METALS		
Aluminum, High Purity	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 99.5 min.
Aluminum 2S	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 99
Copper, Deoxidized	Amer. Brass Co., Waterbury, Conn.	Cu, 99.90+; P, 0.01
Copper, Deoxidized	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 99.9+; P, 0.02
Copper, Deoxidized	Mueller Brass Co., Port Huron, Mich.	Cu, 99.9+; P, 0.01-0.04
Copper, Oxygen-free	U. S. Metals Refining Co., New York, N. Y.	Cu, 99.98
Iron, Armco Ingot	Amer. Rolling Mill Co., Middletown, Ohio	Fe; S, 0.025; Mn, 0.017; C, 0.012; P, 0.005
Iron, Genuine Wrought	Reading Iron Co., Reading, Pa.	Fe, 98.8; P, 0.15; C, 0.03; S, 0.025; 0.03
Iron, Genuine Wrought	A. M. Byers Co., Pittsburgh, Pa.	Fe; Mn, <0.05; P, 0.10-0.12; C, 0.04 max.; Si, 0.1-0.15; S, 0.03 max.
Lead, Chemical	National Lead Co., New York, N. Y.	Pb, 99.94; Cu, 0.06
Lead, Tellurium	National Lead Co., New York, N. Y.	Pb, 99.94; Te, 0.06
Nickel	International Nickel Co., New York, N. Y.	Ni, 99-99.3
Silver, Fine	Handy & Harman, New York, N. Y.	Ag, 99.9
Tantalum	Fansteel Products Co., North Chicago, Ill.	Ta
Tin	National Lead Co., New York, N. Y.	Sn, 99.8+

NON-FERROUS ALLOYS

Acimet	Cleveland Brass Mfg. Co., Cleveland, Ohio	Hard-lead
Admiralty	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 70; Zn, 29; Sn, 1
Advance	Driver-Harris Co., Harrison, N. J.	Ni, 45; Cu, 55
Alclad 17ST	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 94; Cu, 4; Mg, 0.5; Mn, 0.5; coated with Al, 99.7+
Alcumite	Duriron Co., Dayton, Ohio	Cu; Al, 9; Fe, 1.25
Alcun G	Seovill Mfg. Co., Waterbury, Conn.	Cu, 70; Zn, 27; Al, 2; Ni, 1
Aluminum Bronze	Amer. Brass Co., Waterbury, Conn.	Cu, 90-95; Al, 5-10; Fe; Sn; Mn
Aluminum 3S	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 97; Mn, 1.25
Aluminum 52S	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 96; Cr, 0.25; Mg, 2.25
Aluminum 53S	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 97.2; Cr, 0.25; Mg, 1.25, Si, 0.7
Aluminum, Cast 43	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 92.6; Si, 5
Aluminum, Cast 47	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 85; Si, 12.5

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Aluminum, Cast 190	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 99
Aluminum, Cast 195	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 93; Cu, 4.3
Aluminum, Cast 214	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 95.30; Mg, 3.8
Aluminum, Cast 355	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 92; Mg, 0.5; Si, 5; Cu, 1.25
Aluminum, Cast 356	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 91.50; Mg, 0.3; Si, 7
Amaloy	Amer. Mach. & Foundry Co., New York, N. Y.	Pb, 99; Sn, 1
Ambrac A	Amer. Brass Co., Waterbury, Conn.	Cu, 75; Ni, 20; Zn, 5
Ampco 18	Ampco Metal, Milwaukee, Wis.	Cu, 84.75; Al, 11.4; Fe, 3.8
Anti-Acid Metal	H. Kramer & Co., Chicago, Ill.	Cu, 75; Sn, 10; Pb, 15
Antimonial Lead (Hard Lead)	National Lead Co., New York, N. Y.	Pb, 94; Sb, 6
Atlas 89	Ampco Metal, Milwaukee, Wis.	Cu, 89; Al, 10; Fe, 1
Barberite	Barber Asphalt Co., Buffalo, N. Y.	Cu, 88.5; Ni, 5; Sn, 5; Si, 1.5
Beryllium Copper	Amer. Brass Co., Waterbury, Conn.	Cu, 97.75; Be, 2.25
Beryllium Copper	Riverside Metal Co., Riverside, N. J.	Cu, 97.75; Be, 2.25
Blackor	Blackor Co., Los Angeles, Calif.	WcC, 90+
Borium	Stoody Company, Whittier, Calif.	WcC
Calite N	Calorizing Co., Pittsburgh, Pa.	Fe; Ni, 64-68; Cr, 17-20;
Commercial Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 90; Zn, 10
Corvic Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 98.5; Sn, 1.5
Cramp Alloy 78	Cramp Brass & Ir. Fdries Co., Philadelphia, Pa.	Cu, 89; Al, 9; Fe, 2
Cu-Lead-It	Cu-Lead-It Bronze Bearing Metal Co., Los Angeles, Calif.	Cu, 50-65; Pb, 27-50; Sn, 2-8
Cupron	Gilby Wire Co., Newark, N. J.	Ni, 45; Cu, 55
Davis Metal	Chapman Valve Mfg. Co., Indian Orchard, Mass.	Cu, 67; Ni, 25; Fe, 6; Mn, 1; Pb, 0.8; Si, 0.3; C, 0.20 max.
Dowmetal	Dow Chemical Co., Midland, Mich.	Mg, 89.8-95.7; Al, 4-10; Mn, 0-2 0.3
Duronze	Bridgeport Brass Co., Bridgeport, Conn.	Cu, 97; Sn, 2; Si, 1
Everbrite	Amer. Manganese Bronze Co., Philadelphia, Pa.	Cu, 60; Ni, 30; Fe, 3; Si, 3; Cr, 3
Everdur A	Amer. Brass Co., Waterbury, Conn.	Cu, 96; Si, 3; Mn 1
Everdur B	Amer. Brass Co., Waterbury, Conn.	Cu, 98.25; Si, 1.5; Mn, 0.25
Free-Cutting Phos. Bronze	Amer. Brass Co., Waterbury, Conn.	Cu, 88; Sn, 4; Pb, 4; Zn, 4
G-60	La Bour Co., Elkhart, Ind.	Ni, 63; Cr, 24; Cu, 5; Mo, 4; W, 2; Si, 0.80; Fe, 1; Mn, 0.20; C, 0.06

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Hardware Bronze;	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 89; Zn, 9; Pb, 2
Hastelloy A	Haynes Stellite Co., Kokomo, Ind.	Ni, 58; Fe, 20; Mo, 20; Mn, 2
Hastelloy C	Haynes Stellite Co., Kokomo, Ind.	Ni, 58; Mo, 17; Cr, 14; Fe, 6; W, 5
Hastelloy D	Haynes Stellite Co., Kokomo, Ind.	Ni, 85; Si, 10; Cu, 3; Al, 1.5
Herculoy	Revere Copper and Brass, Taunton, Mass.	Cu, 95.25; Zn, 1; Sn, 0.5; Si, 3.25
High Brass	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 67; Zn, 33
Hytensil Bronze	Amer. Manganese Bronze Co., Philadelphia, Pa.	Cu, 63; Zn, 23; Al, 4; Fe, 3; Mn, 3
Illum G	Burgess-Parr Co., Moline, Ill.	Fe; Ni, 55; Cr, 24; Cu, 8; Mo, 4; Mn, 2; W, 2
Illum No. 85	Burgess-Parr Co., Moline, Ill.	Ni, 53; Cr, 21; Cu, 6; Fe, 13; Mo, 3.5
Inconel	International Nickel Co., New York, N. Y.	Ni, 80; Cr, 14; Fe, 6
Jewell-Alloy	Jewell-Alloy & Malleable Co., Buffalo, N. Y.	Ni; Cr;
Konal	Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.	Ni; Co, 18; Fe, 6; Ti, 2.5
Monel Metal	International Nickel Co., New York, N. Y.	Ni, 65-70; Cu, 26-30; Fe, < 3; Mn, < 1.5; Si < 0.25; C < 0.25
Mueller 600 Metal	Mueller Brass Co., Port Huron, Mich.	
Nickel Aluminum Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 92; Ni, 4; Al, 4
Nickel Silver	Gilby Wire Co., Newark, N. J.	All grades
Nickel Silver 18%	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 65; Ni, 18; Zn, 17
Nickel Silver 18% A	Amer. Brass Co., Waterbury, Conn.	Cu, 65; Ni, 13; Zn, 17
Nickel Silver 18% B	Amer. Brass Co., Waterbury, Conn.	Cu, 55; Zn, 27; Ni, 18
Nichrome	Driver-Harris Co., Harrison, N. J.	Fe, 25; Cr, 15; Ni, 60
Nichrome S	Driver-Harris Co., Harrison, N. J.	Fe, 55; Cr, 17; Ni, 25; Si, 3
Nichrome III	Driver-Harris Co., Harrison, N. J.	Cr, 15; Ni, 85
Nichrome V	Driver-Harris Co., Harrison, N. J.	Cr, 20; Ni, 80
Olympic Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 96.25; Zn, 0.75; Si, 3
Omega Nickel Silver 18% A	Riverside Metal Co., Riverside, N. J.	Cu, 66; Ni, 18; Zn, 16
Omega Nickel Silver 18% B	Riverside Metal Co., Riverside, N. J.	Cu, 55; Ni, 18; Zn, 27
Omega Phos. Bronze A	Riverside, Metal Co., Riverside, N. J.	Cu, 95.5; Sn, 4.3; P, 0.2
Omega Phos. Bronze B	Riverside Metal Co., Riverside, N. J.	Cu, 91.85; Sn, 8; P, 0.15
Omega Phos. Bronze 10%	Riverside Metal Co., Riverside, N. J.	Cu, 90; Sn, 10; P
Phosphor Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 95; Sn, 5
Phosphor Bronze	Bunting Brass & Bronze Corp., Toledo, Ohio	Cu, 83; Pb, 7; Zn, 3; Sn, 7
Phosphor Bronze A	Amer. Brass Co., Waterbury, Conn.	Cu, 95; Sn, 5; P
Phosphor Bronze C	Amer. Brass Co., Waterbury, Conn.	Cu, 92; Sn, 8; P
Phosphor Bronze D	Amer. Brass Co., Waterbury, Conn.	Cu, 90; Sn, 10
P-M-G Metal	Phelps-Dodge Copper Prod. Corp., New York, N. Y. Cramp Brass and Iron Found- ries Co., Philadelphia, Pa., (licensee)	Cu, 95; Si, 3.5; Fe, 1.5
Q-Alloy A +	General Alloys Co., Boston, Mass.	Ni, 66-68; Cr, 19-21
R-50	La Bour Co., Elkhart, Ind.	Ni, 54; Cr, 24; Fe, 10; Cu, 5; Mo, 3.6; W, 1.8; Si, 0.80; Mn, 0.30
Red Brass	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 85; Zn, 15
Red Brass 85%	Amer. Brass Co., Waterbury, Conn.	Cu, 85; Zn, 15
Resistac	Amer. Manganese Bronze Co., Philadelphia, Pa.	Cu, 88; Al, 10; Fe, 2
Silicon Nickel	Gilby Wire Co., Newark, N. J.	
Sterling Silver	Handy & Harman, New York, N. Y.	Ag, 92.5; Cu, 7.5
Stellite 1	Haynes Stellite Co., Kokomo, Ind.	Co, 50; Cr, 30; W, 15.5
Stellite 6	Haynes Stellite Co., Kokomo, Ind.	Co, 65; Cr, 30; W, 4
Stellite 12	Haynes Stellite Co., Kokomo, Ind.	Co, 60; Cr, 30; W, 8

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Super Nickel	Amer. Brass Co., Waterbury, Conn.	Cu, 70; Ni, 30
Superstrength Bronze	Cramp Brass & Iron Fdries, Co., Philadelphia, Pa.	Cu, 63; Zn, 27; Al, 6; Mn, 1; Fe, 3
Tobin Bronze	Amer. Brass Co., Waterbury, Conn.	Cu, 60; Zn, 39.25; Sn, 0.75
Tophet A	Gilby Wire Co., Newark, N. J.	Ni, 80; Cr, 20
Tuf-Stuf	Mueller Brass Co., Port Huron, Mich.	Cu, 85-89; Al, 8-14; Fe, 2-4; Mn

FERROUS ALLOYS

Adamite	Mackintosh-Hemphill Co., Pittsburgh, Pa.	Fe; Cr, 1; Ni, 0.75
Allegheny Metal A	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.11 max.
Allegheny Metal A Ti	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.2 max.; Ti, 4xC
Allegheny Metal B	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, 0.08- 0.20
Allegheny Metal B Ti	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, 0.2 max.; Ti, 4xC
Allegheny Metal C	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.08-0.2
Allegheny Metal Free-Machining	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.08- 0.2; S, 0.30
Allegheny Metal Amo	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.11 max.; Mo, 2-4
Allegheny Ohmaloy	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 12-14; Ni, 0.5 max.; C, 0.12 max.; Al, 4-4.5
Allegheny 22	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 19-22; Ni, 9-12; C, 0.08- 0.2
Allegheny 22 Sp.	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 19-22; Ni, 9-12; C, 0.11 max.
Allegheny 33	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 12-15; C, 0.12 max.
Allegheny 33 Free-Machining	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 12-15; C, 0.12 max.; S, 0.4 max.
Allegheny 33 Non-Hardening	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 11.5-13.5; Ni, 0.5 max.; C, 0.08 max.; Al, 0.1-0.25
Allegheny 33 Turbine	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 11.5-13; C, 0.12 max.
Allegheny 33W	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 12-15; C, 0.12 max.; W, 2.5-3.5
Allegheny 44	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 24-26; Ni, 11-13; C, 0.2 max.
Allegheny 46	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 4-6; C, 0.1-0.25
Allegheny 55	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 23-30; C, 0.35 max.
Allegheny 66	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 15-18; C, 0.12 max.
Allegheny 66W	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 15-18; C, 0.12 max.; W, 2.5-3.5
Allegheny 67	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 18-23; C, 0.12 max.
Allegheny 2520	Allegheny Steel Co., Brackenridge, Pa.	Fe; Cr, 24-26; Ni, 19-21; C, 0.25 max.
Alloy 104	Jessop Steel Co., Washington, Pa.	Fe; Cr, 4.5-6.5; W, 0.75-1
Amaco Alloy F1	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; Cr, 16-19; Ni, 35-38
Amaco Alloy F 3	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; Cr, 26-29; Ni, 0-3
Amaco Alloy F 5	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; Cr, 18-21; Ni, 62-65
Amaco Alloy F 6	Amer. Manganese Steel Co., St. Louis, Mo.	Cr, 12-15; Ni, 60-63
Amaco Alloy F 8	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; Cr, 18-21; Ni, 8-11
Amaco Alloy F 10	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; Cr, 26-29; Ni, 10-13
Amaco Manganese Steel	Amer. Manganese Steel Co., St. Louis, Mo.	Fe; C, 1-1.4; Mn, 10-14
Armco	Amer. Rolling Mill Co., Middletown, Ohio	Fe; Cu
Armco 18-8	Amer. Rolling Mill Co., Middletown, Ohio	Fe; Cr, 17-20; Ni, 8-10; C, 0.05 and 0.20 max.
Armco 17	Amer. Rolling Mill Co., Middletown, Ohio	Fe; Cr, 15-18; C, 0.12 max.
Avesta 249	A. Johnson & Co., New York, N. Y.	Fe; Cr, 17.2; C, max. 0.10
Avesta 249 H	A. Johnson & Co., New York, N. Y.	Fe; Cr, 17.2; C, max., 0.25
Avesta 254	A. Johnson & Co., New York, N. Y.	Fe; Cr, 18.5; Ni, 21.5; C, max. 0.10
B & W 440	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 4-6; Mo, 0.5

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
B & W 600	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 18; Ni, 8; C, 0.10
B & W 640	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 18; Ni, 8; Mo, 3.5; C, 0.10
B & W 650	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 23; Ni, 11; C, 0.10
B & W 700	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 18; Ni, 65; C, 0.6
B & W 800	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 25; Ni, 11; C, 1.25
B & W 900	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 18; C, 0.15
B & W 950	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 28; C, 0.25
B & W 1100	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 25; Ni, 21; C, 0.25
B & W 1500	Babcock & Wilcox Co., New York, N. Y.	Fe; Cr, 28; Ni, 8; C, 0.25
Bethadur 1	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 12-15; Ni, 0.5 max.; C, 0.12 max.
Bethadur 2	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, > 0.08
Bethadur 2 A	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.01; max.
Bethadur 2 B	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, > 0.08
Bethadur 2 C	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, 0.08 max.
Bethadur 2 D	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 19-21; Ni, 9-11; C, > 0.08
Bethadur 2 E	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 19-21; Ni, 9-11; C, 0.08 max.
Bethadur 3	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 8-10; Ni, 17-19; C, 0.15 max.
Bethadur 4	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 16-18; Ni, 0.5 max.; C, 1.12 max.
Bethadur 5	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 20-22; Ni, 0.5 max.; C, 0.12 max.
Bethadur 6	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 12-15; Ni, 0.5 max.; C, 0.3-0.4
Bethadur 7	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 16-18; Ni, 0.5 max.; C, 0.6-0.7
Bethadur 8	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 16-18; Ni, 0.5 max.; C, 1.1-1.2
Bethadur 9	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 24-26; Ni, 0.5 max.; C, 0.3 max.
Bethalon A	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 12-15; Ni, 0.5 max.; C, 0.12 max.; Mo, 0.4
Bethalon B	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.10; Mo, 0.4
Bethlehem 4-6 Chromium	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 4-6; C, 0.1-0.25; Si, 0.3 max.; or 1-1.35
Calduro 13-2	Warman Steel Casting Co., Los Angeles, Calif.	Fe; Cr, 12.5-15; Ni, 1.5-2.5; C, 0.20 min.
Calite A;	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 15; Ni, 35
Calite B;	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 9; Ni, 21
Calite B-28	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 24-26; Ni, 8-10
Calite E	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 18; Ni, 8
Calite S	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 18
Calite S-28	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 28
Calite NCT-3	Calorizing Co., Pittsburgh, Pa.	Fe; Cr, 25; Ni, 18
Calmar 18-8	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 17-20; Ni, 7-10; C, 0.16 min.
Calmar 18-8M	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 17-20; Ni, 7-10; C, 0.16 min.; Mo, 3-4.5
Caloxo 18	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 16-20; C, 0.16 min.
Caloxo 18-2	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 16-20; Ni, 1.5-2.5; C, 0.2 min.
Caloxo 26	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 25-30; C, 0.25 min.
Caloxo 25-20	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 23-27; Ni, 17-21; C, 0.2 min.
Caloxo 25-20M	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 23-27; Ni, 17-21; C, 0.2 min.; Mo, 3-4.5
Caloxo 26-10	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 27-30; Ni, 8-12; C, 0.25 min.
Caloxo 28-10M	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 27-30; Ni, 8-12; C, 0.25 min.; Mo, 3-4.5
Caloxo 26-4	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 25-30; Ni, 2.5-4; C, 0.25 min.
Caloxo 8-18	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 7-10; Ni, 17-20; C, 0.16 min.
Caloxo 15-25	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 14-17; Ni, 23-27; C, 0.2 min.

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Caloxo 15-25M	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 14-17; Ni, 23-27; C, 0.2 min.; Mo, 3-4.5
Caloxo 15-35	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 14-17; Ni, 33-37; C, 0.20 min.
Carpenter Stainless Steel 1	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 12-14; C, 0.10
Carpenter Stainless Steel 2	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 13; C, 0.30
Carpenter Stainless Steel 3	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 20; Cu, 1; C, 0.30
Carpenter Stainless Steel 4	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 18; Ni, 9; C, 0.10
Carpenter Stainless Steel 5	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 14; 8, 0.30; C, 0.10
Carpenter Stainless Steel 6	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 17; C, 0.10
Carpenter Stainless Steel 8	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 18; Ni, 9; Se, 0.25; C, 0.10
Carpenter Stainless N1	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 13; C, 0.10; Ni, 2
Carpenter Stainless 2B	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 17; C, 0.95
Carpenter V-Chrome Steel	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 4-6; C, as specified
Chromax	Driver-Harris Co., Harrison, N. J.	Fe, 50; Ni, 35; Cr, 15
Chromax	Empire Steel Castings, Reading, Pa.	Fe; Cr, 1.25; Ni, 0.50; Mo, 0.35; C, 0.35
Chrome-Iron	Driver-Harris Co., Harrison, N. J.	Fe; Cr, 25-28
Chromel 502	Hoskins Mfg. Co., Detroit, Mich.	Fe, 38-48; Ni, 30-34; Cr, 18-22; Mn, 2; C, 0.50 max.
Chromel 670	Hoskins Mfg. Co., Detroit, Mich.	Fe; Cr, 22-24; Ni, 10-12
Cimet	Driver-Harris Co., Harrison, N. J.	Fe; Cr, 27; Ni, 11
Circle L-3	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.25; Mo, 0.40; C, 0.45; Mn, 1.4
Circle L-4	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.25-2; Mo, 0.5-1; C, 0.5-0.8; Mn, 1-1.5
Circle L-6	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Ni, 1.75; Mo, 0.25; C, 0.18
Circle L-8	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.5; V, 0.5; C, 0.25
Circle L-10	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 5; M, 0.50; C, 0.20
Circle L-11	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 18.5; C, 0.25
Circle L-12	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 13; Ni, 0.50 max.; C, 0.10
Circle L-13	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 13; Ni, 0.50 max.; C, 0.35
Circle L-14	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 20; Cu, 1.0; Ni, 0.50 max.; C, 0.30
Circle L-15	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28.5; Ni, 0.50 max.; C, 0.30
Circle L-16	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28; C, 2.25
Circle L-22	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 19; Ni, 9; C, 0.07 max.
Circle L-23	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 19; Ni, 9; C, 0.15
Circle L-24	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Ni, 20; Cr, 9; C, 0.15
Circle L-31	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28; Ni, 11; C, 0.25
Circle L-32	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 16; Ni, 35; C, 0.50
Colonial 410	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys Steel Co., Latrobe, Pa.	Fe; Cr, 13.5; Ni, 1; C, 0.12 max.
Colonial 410 F		Fe; Cr, 13.5; Ni, 1; 8, 0.25; C, 0.12 max.
Colonial 430		Fe; Cr, 13.5; Ni, 1; Mo, 0.60; C, 0.35
Colonial 610		Fe; Cr, 17; Ni, 1; C, 0.12 max.
Colonial 610 F		Fe; Cr, 17; Ni, 1; 8, 0.25; C, 0.12 max.
Colonial 795		Fe; Cr, 17.25; Ni, 1; C, 0.95
Colonial C-2		Fe; Cr, 17; C, 0.12 max.
Colonial C-2 F		Fe; Cr, 17; 8, 0.25; C, 0.12 max.
Colonial F M S		Fe; Cr, 13.5; 8, 0.25; C, 0.12 max.
Comet	Driver-Harris Co., Harrison, N. J.	Fe; Cr, 5; Ni, 30
Cor-R-Loy	Wheeling Steel Corp., Wheeling, W. Va.	Mild steel with 0.2-0.25 Cu
Corrosiron	Pacific Foundry Co., San Francisco, Calif.	Fe; Si, 14.5; C, 0.8-1

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Cramp Alloy 8	Cramp Brass & Iron Fdries. Co., Philadelphia, Pa.	Electric furnace Ni-Cr-Iron
Crocar	Vanadium-Alloys Steel Co., Latrobe, Pa.	Fe; Cr, 12; C, 2.2; V, 0.80; Co, 0.50
Cromin D	Gilby Wire Co., Newark, N. J.	Fe; Cr, 2; Ni, 35
Cyclops 17 Metal	Universal Steel Co., Bridgeville, Pa. Cyclops Steel Co., Titusville, Pa.	Fe; Cr, 8; Ni, 20
Defiheat	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 23-30; Mn, 0.25-0.8; C, 0.02 max.
Defirust	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 12-15; Ni, 0.50 max.; Mn, 0.25-0.6; C, 0.10 max.
Defirust, Machining	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 12-15
Defirust, special	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 15-18; Ni, 0.50 max.; Mn, 0.25-0.6; C, 0.10 max.
Defirust, Turbine	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 11.5-13
Defistain	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 18-20; Ni, 6-10; Mn, 0.25-0.60; C, 0.08-0.2
Defistain	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 18; Ni, 8; C, max. 0.11
Defistain, Machining	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 18; Ni, 8
Defistain, special	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 19; Ni, 9; C, 0.08-0.20
Defistain, special	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 19; Ni, 9; C, max. 0.11
Dopplooy	Sowers Mfg. Co., Buffalo, N. Y.	Fe; Cr, 2.5; Ni, 17-20; C, 3; Si, 2; S, 0.15; P, 0.1; Mn, 0.8
Duraloy A	Duraloy Co., New Cumberland, W. Va.	Fe; Cr, 27-30; Mn, 0.60; C
Duraloy B	Duraloy Co., New Cumberland, W. Va.	Fe; Cr, 16-18; C
Duraloy C	The Duraloy Co., New Cumberland, W. Va.	Fe; Cr, 14
Duraloy N	Duraloy Co., New Cumberland, W. Va.	Fe; Cr, 24-28; Ni, 10-12; C
Duraloy 18-8	The Duraloy Co., New Cumberland, W. Va.	Fe; Cr, 18; Ni, 8
Durco	Duriron Co., Dayton, Ohio	Fe; Cr, 12; C, 0.10-0.12
Durco	Duriron Co., Dayton, Ohio	Fe; Cr, 18; C, 0.10
Durco	Duriron Co., Dayton, Ohio	Fe; Cr, 28; C, 0.15
Durco KA2S	Duriron Co., Dayton, Ohio	Fe; Cr, 18; Ni, 8; C, 0.07 max.
Durco KA2SMo	Duriron Co., Dayton, Ohio	Fe; Cr, 18; Ni, 8; Mo, 4; C, 0.07 max.
Durco 26-12	Duriron Co., Dayton, Ohio	Fe; Cr, 26; Ni, 12
Durco 30-15	Duriron Co., Dayton, Ohio	Fe; Cr, 30; Ni, 15
Durichlor	Duriron Co., Dayton, Ohio	Fe; Si, 14.5; Mo, 3
Durimet	Duriron Co., Dayton, Ohio	Fe; Ni, 23; Cr, 19; Si, 3; Mo, 1; Cu, 1; C, 0.07 max.
Duriron	Duriron Co., Dayton, Ohio	Fe; Si, 14.5; C, 0.8; Mn, 0.35
Duro-Gloss C 1	Jessop Steel Co., Washington, Pa.	Fe; Cr, 12-15;
Duro-Gloss C 2	Jessop Steel Co., Washington, Pa.	Fe; Cr, 16-18;
Duro-Gloss C 3	Jessop Steel Co., Washington, Pa.	Fe; Cr, 20-22;
Duro-Gloss C 4	Jessop Steel Co., Washington, Pa.	Fe; Cr, 25-29;
Duro-Gloss Free Machining	Jessop Steel Co., Washington, Pa.	Fe; Cr, 12-15; S, 0.25-0.35
Economet	General Alloys Co., Boston, Mass.	Fe; Cr, 10; Ni, 30
Elcomet K	La Bour Co., Elkhart, Ind.	Fe, 48; Cr, 24; Ni, 20; Cu, 3.5; Mo, 2; Si, 1.25; Mn, 0.30; C, 0.13
Empire 18	Empire Steel Castings, Reading, Pa.	Fe, 72; Cr, 18; C, 0.20
Empire 18-8	Empire Steel Castings, Reading, Pa.	Fe, 74; Cr, 18; Ni, 8; C, 0.15
Empire 24-12	Empire Steel Castings, Reading, Pa.	Fe, 64; Cr, 24; Ni, 12; C, 0.25
Empire 25-5	Empire Steel Castings, Reading, Pa.	Fe, 68; Cr, 28; Ni, 2; C, 2
Empire 30	Empire Steel Castings, Reading, Pa.	Fe, 70; Cr, 30; C, 0.30
Empire 35-15	Empire Steel Castings, Reading, Pa.	Fe, 50; Cr, 35; Ni, 15; C, 0.35;
Empire 60-20	Empire Steel Castings, Reading, Pa.	Cr, 60; Ni, 20; Fe, 20; C, 0.50
Empire D	Empire Steel Castings, Reading, Pa.	Fe; Cr, 28; Ni, 16; Mo, 4

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Enduro 18-8	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 17-19; Ni, 7-11; Mo; 8e
Enduro 20-10	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 19-22; Ni, 9-12
Enduro 20-25	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 19-21; Ni, 24-26
Enduro 4-6 Chromium	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 4-6; Mo; W
Enduro AA	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 18-20; Ni, 8-10
Enduro HC	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 23; Mn, 0.50 max.; Si 0.50 max.; Ni, 0.30 max.; C, 0.20 max.
Enduro HCN	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 24-26; Ni, 11-13; Mn, 1.50 max.; Si, 0.50 max.; C, 0.20 max.
Enduro S	Republic Steel Corp., Youngstown, Ohio	Fe; Cr, 11.5-15
Evansteel 2;	Chicago St. Fdry. Co., Chicago, Ill.	Fe; Cr; Ni
Fahrte N-1	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Ni, 38; Cr, 18; Mn, 0.5-1; C, 0.3-1
Fahrte N-2	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 18; Ni, 8; Mn, 0.50; C, 0.15-0.25
Fahrte N-3	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 24; Ni, 9; Mn, 0.35-0.75; C, 0.2-1
Fahrte N-4	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Ni, 20; Cr, 10; Mn, 0.5-0.75 C, 0.40
Fahrte N-5	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 12; Ni, 60
Fahrte N-6	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 15; Ni, 65
Fahrte N-7	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 25-28;
Fahrte N-6 Mo;	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 15; Ni, 65; Mo, 5
Fahrte N-8	Ohio St. Fdry. Co., Springfield, Ohio	Fe; Cr, 20-26; Ni, 18-20
Fecraloy	Gilby Wire Co., Newark, N. J.	Fe; Cr, 15; Al, 5
Fire Armor	Michiana Products Corp., Michigan City, Ind.	Fe; Ni, 65; Cr, 20; C, 0.50 max.
Formite	Colombia Tool Steel Co., Chicago Heights, Ill.	Fe; Cr; Vd; W
Genesee KA 2	The Symington Co., Rochester, N. Y.	Fe; Cr, 18; Ni, 8
Genesee Ni-Hard	The Symington Co., Rochester, N. Y.	Fe; Cr, 2; Ni, 4.5
Genesee Ni-Resist	The Symington Co., Rochester, N. Y.	Fe; Cr, 2; Ni, 13; Cu, 6
Genesee 212	The Symington Co., Rochester, N. Y.	Fe; Cr, 12-16; C, 0.2 max.
Genesee 255	The Symington Co., Rochester, N. Y.	Fe; Cr, 4-6; Mo, 0.5
Genesee 280	The Symington Co., Rochester, N. Y.	Fe; Cr, 28; Ni, 10
Genesee 303	The Symington Co., Rochester, N. Y.	Fe; Cr, 25; Ni, 20
Genesee 315	The Symington Co., Rochester, N. Y.	Fe; Cr, 1.5; Ni, 3
Genesee 405	The Symington Co., Rochester, N. Y.	Fe; Cr, 1; Ni, 0.75; C, 0.45; Mn, 1.5; Mo, 0.3;
Genesee 412	The Symington Co., Rochester, N. Y.	Fe; Mn, 11-14
Genesee 460	The Symington Co., Rochester, N. Y.	Fe; Cr, 1; Ni, 3; C, 0.6; Mo, 0.3
Hascrome 157	Haynes Stellite Co., Kokomo, Ind.	Fe, 84; Cr, 12; Mn, 4
Heat Resisting 4	Jessop Steel Co., Washington, Pa.	Fe; Cr, 8-9; Ni, 21-22;
Heat Resisting 5	Jessop Steel Co., Washington, Pa.	Fe; Cr, 25-29; Ni, 12-14
Hi-Gloss	Jessop Steel Co., Washington, Pa.	Fe; Cr, 17.5-20; Ni, 7.5-10; Se, 0.22-0.26
Hi-Gloss Free Machining	Jessop Steel Co., Washington, Pa.	Fe; Cr, 17.5-19; Ni, 7.5-9; P, 0.13-0.16
Hi-Tem Irons	Bethlehem Fdry. & Mach. Co., Bethlehem, Pa.	According to requirement
HR-5M	Standard Alloy Co., Cleveland, Ohio	Fe, 50; Cr, 25; Ni, 20; Mo, 2.5-4; Mn, 0.40; C, 0.30
Hyglo Stainless	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 16.5-18; C, 0.6-0.7
Ing-A-Clad	Ingersoll Steel & Disc. Co., Chicago, Ill.	Clad with 18-8, 20-10, and 23-11 stainless
KA 2	Driver-Harris Co., Harrison, N. J.	Fe; Cr, 18; N: 8
Lesco H	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 18-23; C, 0.10 max.
Lesco HH	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 24-30; C, 0.20 max.
Lesco L	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 11.5-13; C, 0.10 max.
Lesco LM	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 13-15; C, 0.10 max.

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent	MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Lesco LS	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 11.5-13; C, 0.12 max. Mn, 0.3-0.5; Si, 0.5 max.	Nickel-clad Steel	Lukens Steel Co., Coatesville, Pa.	Pure nickel cladding on steel base
Lesco LMS	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 13-15; C, 0.12 max.; Mo, 0.3-0.5	Ni-Hard	International Nickel Co., New York, N. Y.	Fe; Ni, 4.4-4.6; C, 2.75-3.6; Cr, 1.4-1.6; Si, 0.5-1.5; Mn, 0.3-0.7
Lesco M	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 15-18; C, 0.10 max.	Ni-Resist	International Nickel Co., New York, N. Y. Licensees	Fe; Ni, 12-13; Cu, 5-7; Cr, 1.5-4; C, 2.75-3.1; Mn, 1-1.5; Si, 1.25-2
Lesco Reg. Stainless	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 13-14; C, 0.3-0.4	Ni-Resist, Copper- free	International Nickel Co., New York, N. Y.	Fe; Ni, 15-20; Cr, up to 2.5; C, 2.2-3; Mn, 1-1.5; Si, 0.6-2
Lesco 18-8	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 17-20; Ni, 7-10; C, 0.20 max.	Ni-Tensyliron	International Nickel Co., New York, N. Y.	Fe; Ni, 1-4
Lesco 18-8-8	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 17-20; Ni, 7-10; C, 0.07 max.	Nitralloy 125-135	Crucible Steel Co., New York, N. Y.	Fe; Al, 0.9-1.4; Cr, 0.9-1.4; Mn, 0.4-0.6; Mo, 0.15-0.25; C, 0.2-0.4
Lesco 25-12	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 24-26; Ni, 11-13; C, 0.20 max.	Nitralloy 225 and FM 225	Crucible Steel Co., New York, N. Y.	Fe; Al, 1-1.5; Mn, 0.4-0.7; Mo, 0.6-1; C, 0.25-0.35
Lusterite Stainless	Latrobe Elec. Steel Co., Latrobe, Pa.	Fe; Cr, 16.5-18; C, 0.9-1	Ohio Air Die	Vanadium-Alloys Steel Co., Latrobe, Pa.	Fe; Cr, 12; C, 1.55; V, 0.85; Mo, 0.80; Co, 0.40
MacHempite	Mackintosh Hemphill Co., Pittsburgh, Pa.	Fe; Ni, 1.5-3.5; Mn, 0.7-4; Cr, 0.1-25; Mo, 0-0.75; C, 0.4-3	Par 1	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr; Co; W
Meehanite Metal	Meehanite Metal Corp., Pittsburgh, Pa. See licensees	Fe; C, 3.0; Si, 0.5-6.0; Mn, 0.4-2 S, 0.05-0.12; P, 0.05-0.10	Par 2	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Low Cr; Ni
Midvaloy 13-80	Midvale Co., Philadelphia, Pa.	Fe; Cr, 15 or less; C, 0.12 or less	Par 3	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 3
Midvaloy 18-8	Midvale Co., Philadelphia, Pa.	Fe; Cr, 18; Ni, 9; C	Par 4	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 25; Ni, 2
Midvaloy 25-10	Midvale Co., Philadelphia, Pa.	Fe; Cr, 24; Ni, 11	Par 5	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 18; Ni, 8
Midvaloy 25-20	Midvale Co., Philadelphia, Pa.	Fe; Cr, 25; Ni, 19.5; C, 0.12	Par 6	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 28; Ni, 10
Midvaloy 26-92	Midvale Co., Philadelphia, Pa.	Fe; Cr, 26.5; Ni, 1.5; C, 0.25	Par 7	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 16; Ni, 35
Midvaloy 30-30	Midvale Co., Philadelphia, Pa.	Fe; Cr, 27; Ni, 30; C, 0.50	Par 8	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 18; Ni, 65
Midvaloy 1835-A	Midvale Co., Philadelphia, Pa.	Fe; Ni, 35; Cr, 18; C, 0.35	Par 9	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 30
Midvaloy A.T.V. 1	Midvale Co., Philadelphia, Pa.	Fe; Ni, 36; Cr, 11-15; C, 0.35	Par 10	Crucible Steel Casting Co., Cleveland, Ohio	Fe; Cr, 15
Midvaloy A.T.V. 3	Midvale Co., Philadelphia, Pa.	Fe; Ni, 26.5; Cr, 14; W, 3.5; C, 0.48	Phoenix	Colombia Tool Steel Co., Chicago Heights, Ill.	Fe; Cr
Milwaloy 7	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.3-0.4; Cr, 1.5-1.75; Vd, 0.6-0.7	Pioneer Metal	Pioneer Alloy Products Co., Cleveland, Ohio	Ni, Cr, Mo, Fe
Milwaloy 13	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.08-0.12; Cr, 12-14	Plykrome	Illinois Steel Co., Chicago, Ill.	Clad with stainless steel
Milwaloy 18	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.30-0.45; Ni, 13-15; Mn, 3.9-4.5	Premier Nickel Chrome	Alloy Metal Wire Co., Moore, Pa.	Ni; 60-62; Fe, 25; Cr, 14-16; C, 0.10
Milwaloy 26	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.08-0.12; Cr, 18-20; Ni, 8-10	Promal	Link Belt Co., Chicago, Ill.	Malleable iron
Milwaloy 38	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.12-0.15; Cr, 28-30; Ni, 8-10	Pyrocast	Pacific Foundry Co., San Francisco, Calif.	Fe; Cr, 22-30
Milwaloy 50	Milwaukee Steel Foundry Co., Milwaukee, Wis.	Fe; C, 0.3-0.4; Cr, 15-18; Ni, 32-36	Pyrasteel	Chicago St. Fdry. Co., Chicago, Ill.	Fe; Cr, 16; Ni, 35
Misco Metal	Michigan Steel Casting Co., Detroit, Mich.	Cr, 15; Ni, 35; Fe	Pyrasteel	Chicago St. Fdry. Co., Chicago, Ill.	Fe; Cr, 14; Ni, 25
Misco B	Michigan Steel Casting Co., Detroit, Mich.	Cr, 24; Ni, 12; Fe	Pyrasteel	Chicago St. Fdry. Co., Chicago, Ill.	Fe; Cr, 26-39; Ni, < 10
Misco C	Michigan Steel Casting Co., Detroit, Mich.	Fe, 57; Cr, 29; Ni, 9; Mn, 0.60; C, 0.25	Q Alloy B	General Alloys Co., Boston, Mass.	Fe; Cr, 12; Ni, 60
Misco HN 1	Michigan Steel Casting Co., Detroit, Mich.	Ni, 65; Cr, 18; Fe, 15; Mn, 0.60; C, 0.50	Q Alloy Chrome C 1	General Alloys Co., Boston, Mass.	Fe; Cr, 26-30
Misco HN 2	Michigan Steel Casting Co., Detroit, Mich.	Cr, 18; Ni, 60; Fe	Q Alloy Chrome C 2	General Alloys Co., Boston, Mass.	Fe; Cr, 16-18
Misco N	Michigan Steel Casting Co., Detroit, Mich.	Cr, 10; Ni, 20; Fe	Q Alloy Chrome C 3	General Alloys Co., Boston, Mass.	Fe; Cr, min. 30; C, 2.5-3
Misco 18-8	Michigan Steel Casting Co., Detroit, Mich.	Cr, 18; Ni, 8; Fe	Q Alloy Chrome CN 1	General Alloys Co., Boston, Mass.	Fe; Cr, 24-26; Ni, 11-13
Misco 30-30	Michigan Steel Casting Co., Detroit, Mich.	Cr, 30; Ni, 30; Fe	Q Alloy Chrome CN 2	General Alloys Co., Boston, Mass.	Fe; Cr, 18-20; Ni, 8-10
Molymet	Gilby Wire Co., Newark, N. J.	Fe; Ni, 45; Mo, 10	Rezistal 2C	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18; Ni, 8, Si, 2.25; C, 0.15 max.
Nationalloy 1	Natl. Forge and Ordnance Co., Irvine, Pa.	Fe; Cr, 18 min.; Ni, 8 min.; C, 0.4 max.	Rezistal KA2	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18; Ni, 8; Mn, 0.65; C, 0.15 max.
Nationalloy 2	Natl. Forge and Ordnance Co., Irvine, Pa.	Fe; Cr, 6 min.; Ni, 18 min.; C, 0.5 max.	Rezistal KA2 Mo	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18; Ni, 8; Mo, 3; C, 0.15 max.
Nationalloy 3	Natl. Forge and Ordnance Co., Irvine, Pa.	Fe; Cr, 12-13.5; C, 0.2 max.	Rezistal KA2ST1	Crucible Steel Co., New York, N. Y.	Fe; Cr, 17-20; Ni, 7.5-10; C, 0.07; Ti, 5xC
NA 1	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 27-29; Ni, 9-11; C, < 0.3	Rezistal 3	Crucible Steel Co., New York, N. Y.	Fe; Cr, 25; Ni, 12; Si, 2.25; C, 0.2 max.
NA 2	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 15-19; Ni, 30-35; C, < 0.3	Rezistal 4	Crucible Steel Co., New York, N. Y.	Fe; Ni, 25; Cr, 18; Si, 2.5; C, 0.2 max.
NA 4	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, < 0.3	Rezistal 7	Crucible Steel Co., New York, N. Y.	Fe; Cr, 25; Ni, 20; Si, 1; C, 0.15 max.
NA 4M	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 18-20; Ni, 8-10; C, < 0.3; Mo, 3.5-4.5	Rezistal 2600	Crucible Steel Co., New York, N. Y.	Fe; Ni, 22.5; Cr, 9; Cu, 1.25; C, 0.30
NA 18	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 16-19; C, < 0.3	Rustless Iron 25-12	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 25; Ni, 12
NA 19	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 28-30; C, 0.5-0.7	Rustless Iron 21% Chrome	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 18-23
NA 65	Natl. Alloy St. Co., Blawnox, Pa.	Fe; Cr, 18-20; Ni, 65-70; C, < 0.3	Silcrome H-17	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 16-18; C, 1-1.1
Nickel-Chromium Cast Iron	International Nickel Co., New York, N. Y.	Fe; Ni, 1.5-1.75; Cr, 0.6-0.8; C, 3- 3.4; Si, 0.9-1.75; Mn, 0.5-0.7; P, < 0.3	Silcrome H-17-EZ	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 16-18; C, 1-1.1; Mn., 0.3- 0.6; Mo, 0.35-0.6
			Silcrome KA2	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 18; Ni, 8; C, 0.09-0.20

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Silcrome KA2S	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 18; Ni, 8; C, max. 0.08; Si, 0.2-0.3
Silcrome KA2EZ	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 18; Ni, 8; C, max. 0.2
Silcrome KA2M	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 18; Ni, 8; C, max. 0.2; Mn, 0.6-1.1; Si, max. 0.75; S, max. 0.03; Mo, 2-4
Silcrome L-12	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 12-14; C, 0.3-0.4;
Silcrome M-17	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 16-18; C, 0.6-0.7
Silcrome RA	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 15-17; C, max. 0.12; Cu, 1; Si, 1
Silcrome RA-EZ	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 15-17; C, max. 0.12
Silcrome 12	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 11.5-13; C, max. 0.12;
Silcrome 12-EZ	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 11.5-13; C, max. 0.12; Mn, 0.4-0.6
Silcrome 12-2	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 12-15; Ni, 1.25-2; C, max. 0.12
Silcrome 17	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 16-18; C, max. 0.12
Silcrome 21	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 18-23; C, max. 0.20
Silcrome 25-12	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 22-25; Ni, 10-13; C, max. 0.2
Silcrome 25-20	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 24-27; Ni, 18-21; C, max. 0.25
Silcrome 28	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 23-30; C, max. 0.20
Silcrome 46-M	Ludlum Steel Co., Watervliet, N. Y.	Fe; Cr, 4-6; C, max. 0.25; Mo, 0.4-0.6
Sivyer 60	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 18.5; Ni, 9; C, 0.10
Sivyer 62	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 24.5; Ni, 12.5; C, 0.18
Sivyer 64	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 29.5; Ni, 9.5; C, 0.25
Sivyer 66	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 13; C, 0.10
Sivyer 67	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 17; C, 0.25
Sivyer 70	Sivyer Steel Casting Co., Milwaukee, Wis.	Fe; Cr, 15; Ni, 35; C, 0.25
Sta-Gloss	Jessop Steel Co., Washington, Pa.	Fe; Cr, 12-14
Sta-Gloss B	Jessop Steel Co., Washington, Pa.	Fe; Cr, 17-18
Stainless A	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 13.5; Mn, 0.35; C, 0.35
Stainless B	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 16.5; C, 0.65
Stainless I	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 13.5; C, 0.12 max.
Stainless Iron C 1	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, max. 15; C, max. 0.12
Stainless Iron C 2	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, 15-18; C, max. 0.12
Stainless Iron C 3	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, 18-23; C, max. 0.35
Stainless Iron C 4	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, 23-30; C, max. 0.35
Stainless Iron 2 FM	Crucible Steel Co., New York, N. Y.	Fe; Cr, 14-15; Mo, 0.55; C, 0.11 max.
Stainless Iron 12	Crucible Steel Co., New York, N. Y.	Fe; Cr, 11.5-15; C, 0.12 max.
Stainless Iron 16	Crucible Steel Co., New York, N. Y.	Fe; Cr, 15-18; C, 0.10 max.
Stainless Iron 18	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18-23; C, 0.10 max.
Stainless Iron 24	Crucible Steel Co., New York, N. Y.	Fe; Cr, 23-30; C, 0.25 max.
Stainless N	Colonial Steel Co., Pittsburgh, Pa.	Fe; Cr, 18.5; Ni, 9; C, 0.12 max.
Stainless U	Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 19; Ni, 9; Mo, 1.50; Cu, 1.25; C, 0.12 max.
Stainless Steel A	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, 8-16; C, >0.12
Stainless Steel A	Henry Diston & Sons, Inc., Tacoma, Philadelphia, Pa.	Fe; Cr, 13-14; C, 0.25-0.35
Stainless Steel A	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 12-15; C, >0.12
Stainless Steel B	American Stainless Steel Co., Pittsburgh, Pa.	Fe; Cr, 16-18; C, >0.12
Stainless Steel B	Henry Diston & Sons, Inc., Tacoma, Philadelphia, Pa.	Fe; Cr, 16-17; C, 0.5-0.6
Stainless Steel B	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 15-18; C, >0.55
Stainless Steel C	Henry Diston & Sons, Inc., Tacoma, Philadelphia, Pa.	Fe; Cr, 12-14; C, 0.12 max.; Mn, 0.4 max.; Si, 0.4 max.

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
Stainless 18-8	Gilby Wire Co., Newark, N. J.	Fe; Cr, 18; Ni, 8
Sterling Nirosta FC	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 14; C, max. 0.12
Sterling Nirosta KA 2	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, 0.08-0.20
Sterling Nirosta KA 2S	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 17-19; Ni, 7-9; C, max. 0.11
Sterling Nirosta 19-9	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, min. 18; Ni, min. 8
Sterling Stainless HHH	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 17; C, 1.05
Sterling Stainless Steel FC	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 14; Mn, 0.40; C, 0.10
Sterling Stainless M	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 15-18; C, max. 0.12
Sterling Stainless MG	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 18-23; C, max. 0.35
Sterling Stainless T	Firth-Sterling Steel Co., McKeesport, Pa.	Fe; Cr, 12-15; C, max. 0.12
Sweetaloy 16	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 83; Cr, 14-18; Mn, 0.50; Si, 0.50; C, < 0.35
Sweetaloy 17	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 73; Cr, 18; Ni, 8; Mn, 0.50; Si, 0.50; C, < 0.20
Sweetaloy 17 Mo	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; Cr, 18; Ni, 8; C, < 0.20; Mo, 2-4
Sweetaloy 17 Mo S	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; Cr, 18; Ni, 8; C, < 0.10; Mo, 2-4
Sweetaloy 17 S	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; Cr, 18; Ni, 8; C, < 0.10
Sweetaloy 17 Se	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; Cr, 18; Ni, 8; C, < 0.20; Se, 0.25
Sweetaloy 18	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 67; Ni, 22; Cr, 10; Mn, 0.50; Si, 0.50; C, < 0.25
Sweetaloy 19	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 71; Cr, 28; Mn, 0.50; Si, 0.50; C, < 0.50
Sweetaloy 20	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 45; Ni, 36; Cr, 18; Mn, 0.50; Si, 0.50; C, < 0.50
Sweetaloy 21	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Ni, 65; Fe, 19; Cr, 15; Mn, 0.50; Si, 0.50; C, < 0.50
Sweetaloy 21 A	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; Cr, 15; Ni, 25; C, < 0.30
Sweetaloy 22	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe, 63; Cr, 24-28; Ni, 10; Mn, 0.50; Si, 0.50; C, < 0.50
Tantiron	Bethlehem Fdry. & Mach. Co., Bethlehem, Pa.	Fe, 84.9; Si, 13.5; C, 1; Mn, 0.4; P, 0.18; S, 0.05
Thermalloy B	Electro Alloys Co., Elyria, Ohio	Fe; Ni, 40; Cr, 20; Si, 1.5; Mn, 1.5; C, 0.40-0.60
Timken DM	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 1.25; Mo, 0.4-0.6; C, 0.12 max.
Timken DM 45	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 1.25; Mo, 0.4-0.6; C, 0.4-0.5
Timken 8-18	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 18; Ni, 8; C, 0.08-0.20
Timken 18-8 S	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 18; Ni, 8; C, 0.11 max.
Timken 19-9	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 19; Ni, 9; C, 0.08-0.20
Timken 19-9 S	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 19; Ni, 9; C, 0.11 max.
Timken 20-10	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 20.5; Ni, 10.5; C, 0.08-0.20
Timken 20-10 S	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 20.5; Ni, 10.5; C, 0.11 max.
Timken 4-6 Chromium	Timken Steel & Tube Co., Canton, Ohio	Fe; Cr, 5; C, 0.15 max.
Toncan Iron	Republic Steel Corp., Mansfield, Ohio	Fe; Cu, 0.40 min.; Mo, 0.05 min.; (C+Mn+P+S+Si) max. 0.25
Tophet C	Gilby Wire Co., Newark, N. J.	Ni, 60; Cr, 15; Fe
Tophet D	Gilby Wire Co., Newark, N. J.	Fe; Cr, 5; Ni, 30
Uniloy 18-18		Fe; Cr, 18; Ni, 8
Uniloy 21-12		Fe; Cr, 21; Ni, 12
Uniloy 24-11		Fe; Cr, 24; Ni, 12
Uniloy 1409	Universal Steel Co., Bridgeville, Pa.	Fe; Cr, 14; C, 0.10
Uniloy 1435	Cyclops Steel Co., Titusville, Pa.	Fe; Cr, 14; C, 0.35
Uniloy 1809		Fe; Cr, 18; C, 0.10
Uniloy 1860		Fe; Cr, 18; C, 0.60
Uniloy 2825		Fe; Cr, 28; C, 0.25
Uniloy 4-6 Chrome		Fe; Cr, 5; C, 0.25 max.
U.S.S. Cor-Ten	Subsidiary Mfg. Cos. of U. S. I. Steel Corp., New York, N. Y.	Fe; Cr, 0.5-1.5; Cu, 0.3-0.5; C, 0.1; Mn, 0.1-0.3; P, 0.1-0.2; S, 0.5; Si, 0.5-1

MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent
U.S.S. 12		Fe; Cr, 11.5-14; C, 0.10
U.S.S. 17		Fe; Cr, 16-19; C, 0.10
U.S.S. 18-8		Fe; Cr, 17-20; Ni, 8-12; C, 0.15
U.S.S. 18-8 Mo		Fe; Cr, 17-20; Ni, 8-12; C, 0.15; Mo, several pct.
U.S.S. 18-8 S	Subsidiary Mfg. Cos. of U.S. Steel Corp., New York, N. Y.	Fe; Cr, 17-20; Ni, 8-12; C, 0.07
U.S.S. Stabilized 18-8	Amer. Sheet & Tin Plate Co. Pittsburgh, Pa.	Fe; Cr, 17-20; Ni, 8-12; C, 0.12; Ti, 0.6
U.S.S. 19-9	Amer. Steel & Wire Co., Chicago, Ill.	Fe; Cr, 18; Ni, 8; C, 0.2
U.S.S. 20-10	Carnegie Steel Co., Pittsburgh, Pa.	Fe; Cr, 19; Ni, 9; C, 0.2
U.S.S. 21	Illinois Steel Co., Chicago, Ill.	Fe; Cr, 20-24; C, 0.10
U.S.S. 25-12	National Tube Co., Pittsburgh, Pa.	Fe; Cr, 22-28; Ni, 12-16; C, 0.25
U.S.S. 27		Fe; Cr, 25-30; C, 0.10
4/6 Cr		Fe; Cr, 4-6; C, 0.15
4/6 Cr-Mo		Fe; Cr, 4-6; C, 0.15; Mo, 0.4-0.65
4/6 Cr-T		Fe; Cr, 4-6; C, 0.15; Ti, 0.75
Verialoy	Driver-Harris Co., Harrison, N. J.	Fe, 70; Cr, 10; Ni, 20
Warman 5	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 4-7; C, 0.18 min.
Warman 5 M	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 4-7; C, 0.18 min.; Mo, 0.5-0.7
Warman 13	Warman Steel Castings Co., Los Angeles, Calif.	Fe; Cr, 11-14; C, 0.12 min.
Wear-Proof MacHempite	Mackintosh-Hemphill Co., Pittsburgh, Pa.	Fe; C, 0.45; Mn, 1.25; Mo, 0.35
X-ite	General Alloys Co., Boston, Mass.	Fe; Ni, 37-39; Cr, 17-19
X-ite B	General Alloys Co., Boston, Mass.	Fe; Cr, 15; Ni, 35
Z-Metal	Chain Belt Co., Milwaukee, Wis.	
Zorite	Michiana Products Corp., Michigan City, Ind.	Fe; Ni, 35; Cr, 15; C, 0.50 max.
48 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 28; Ni, 8; C, 0.50 max.
49 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 18; Ni, 8
55 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 33
63 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 28; Ni, 15
100 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 25; Ni, 12; C, 0.50 max.
111 Alloy	Michiana Products Corp., Michigan City, Ind.	Fe; Cr, 24; Ni, 12; Mo, 3.5

Licenses American Stainless Steel Co., Pittsburgh, Pa. — Allegheny Steel Co., Brackenridge, Pa.; Bethlehem Steel Co., Bethlehem, Pa.; Carpenter Steel Co., Reading, Pa.; Colonial Steel Co., Pittsburgh, Pa.; Columbia Tool Steel Co., Chicago Heights, Ill.; Crucible Steel Co. of America, New York, N. Y.; Henry Diston & Sons, Philadelphia, Pa.; Duraloy Company, Pittsburgh, Pa.; Firth-Sterling Co., McKeesport, Pa.; Halcomb Steel Co., New York, N. Y.; Heppenstall Co., Pittsburgh, Pa.; Jessop Steel Co., Washington, Pa.; Latrobe Electric Steel Co., New York, N. Y.; Ludlum Steel Co., Watervliet, N. Y.; Midvale Co., Philadelphia, Pa.; Republic Steel Corp., Massillon, Ohio; Simonds Saw & Steel Co., Lockport, N. Y.; Union Electric Steel Corp., Pittsburgh, Pa.; Universal Steel Co., Bridgeville, Pa.; Vanadium-Alloys Steel Co., Latrobe, Pa.; Vulcan Crucible Steel Co., Alliquippa, Pa.; Brighton Electric Steel Casting Co., Beaver Falls, Pa.; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Philadelphia, Pa.; Cooper Alloy Foundry Co., Elizabeth, N. J.; Empire Steel Casting Co., Reading, Pa.; Lebanon Steel Foundry, Lebanon, Pa.; Michiana Products Corp., Michigan City, Ind.; Snyer Steel Casting Co., Milwaukee, Wis.; Union Spring & Mfg. Co., New Kensington, Pa.; Wehr Steel Co., Milwaukee, Wis.; Braeburn Alloy Steel Corp., Braeburn, Pa.; Hobart Mfg. Co., Troy, Ohio; National Forge & Ordnance Co., Irvine, Pa.

Licenses Chemical Foundation, New York, N. Y. — Acme Steel Co., Chicago, Ill.; Allegheny Steel Co., Brackenridge, Pa.; American Chain Co. and associate companies, Bridgeport, Conn.; Babcock & Wilcox Co., New York, N. Y.; Baldt Anchor, Chain & Forge Corp., Chester, Pa.; Barium Steel Corp., Canton, Ohio; Bethlehem Steel Co., Bethlehem, Pa.; Bonney-Floyd Co., Columbus, Ohio; Braeburn Alloy Steel Corp., Braeburn, Pa.; Carpenter Steel Co., Reading, Pa.; Chicago Steel Foundry Co., Chicago, Ill.; Colonial Steel Co., Pittsburgh, Pa.; Cooper Alloy Foundry Co., Elizabeth, N. J.; Crane Co., Chicago, Ill.; Crucible Steel Casting Co., Cleveland, Ohio; Crucible Steel Co. of America, New York, N. Y.; Driver Harris Co., Harrison, N. J.; Duncan Foundry & Machine Works, Alton, Ill.; Duraloy Co., Pittsburgh, Pa.; Electric Steel Foundry, Portland, Ore.; Electro-Alloys Co., Elyria, Ohio; Electro Metallurgical Co., New York, N. Y.; Empire Steel Castings, Reading, Pa.; Enterprise Foundry Co., San Francisco, Calif.; Forging and Casting Corp., Detroit, Mich.; General Alloys Co., Boston, Mass.; Globe Steel Tubes Co., Milwaukee, Wis.; Illinois Steel Co., Chicago, Ill.; Ingersoll Steel & Disc Co., New Castle, Ind.; Jessop Steel Co., Washington, Pa.; Kropp Forge Co., Chicago, Ill.; C. E. Larson & Sons, Chicago, Ill.; Latrobe Electric Steel Co., New York, N. Y.; Lebanon Steel Foundry, Lebanon, Pa.; Ludlum Steel Co., Watervliet, N. Y.; Michiana Products Corp., Michigan City, Ind.; Michigan Steel Casting Co., Detroit, Mich.; Midvale Company, Philadelphia, Pa.; Milwaukee Steel Foundry Co., Milwaukee, Wis.; Monarch Foundry Co., Stockton, Calif.; National Forge and Ordnance Co., Irvine, Pa.; Ohio Steel Foundry Co., Lima, Ohio; Pennsylvania Forge Corp., Philadelphia, Pa.; Republic Steel Corp., Youngstown, Ohio; Riverton Steel Co., Pittsburgh, Pa.; Rustless Iron Corp. of America, Baltimore, Md.; Sharon Steel Hoop Co., Sharon, Pa.; Simonds Saw & Steel Co., Lockport, N. Y.; Snyer Steel Casting Co., Milwaukee, Wis.; Standard Alloy Co., Cleveland, Ohio; Superior Steel Corp., Pittsburgh, Pa.; Symington Company, Rochester, N. Y.; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.; Timken Steel & Tube Co., Canton, Ohio; Union Electric Steel Corp., Pittsburgh, Pa.; Universal Steel Co., Bridgeville, Pa.; Warman Steel Casting Co., Los Angeles, Calif.; Washington Iron Works, Seattle, Wash.; Wehr Steel Co., Milwaukee, Wis.; Weirton Steel Company, Weirton, W. Va.; West Leeburg Steel Co., Pittsburgh, Pa.; West Steel Casting Co., Cleveland, Ohio; Wheeling Steel Corp., Wheeling, W. Va.; Whitehead Metal Products Co., New York, N. Y.

Licenses Krupp Nirosta Co., New York — Acme Steel Co.; American Forge Co.; Babcock & Wilcox Tube Co.; Bacon & Matheson Forge Co.; Baldt Anchor, Chain & Forge Co.; Crucible Steel Co. of America; Detroit Seamless Steel Tubes Co.; Henry Diston & Sons; Driver Harris Co.; A. Fink & Sons Co.; Firth-Sterling Steel Co.; Globe Steel Tubes Co.; Griffin Manufacturing Co.; Heppenstall Co.; Ludlum Steel Co.; Luken Steel Co.; American Steel & Wire Co.; Newton Steel Co.; Ohio Seamless Tube Co.; Pennsylvania Forge Corp.; Pittsburgh Steel Co.; Republic Steel Corp.; Sharon Steel Hoop Co.; Spang-Chalfant & Co.; Standley Works; Summerill Tubing Co.; Union Drawn Steel Co.; Wallingford Steel Co.; Calorizing Co.; Chapman Valve Mfg. Co.; Chrome Alloy Products; Cleveland Alloy Products Co.; Duriron Co.; Electric Steel Foundry Co.; General Alloy Co.; Michiana Products Corp.; Millbury Steel Fdry. Co.; Milwaukee Steel Foundry Co.; Monarch Foundry Co.; Pacific Foundry Co., Ltd.; Shawinigan Stainless Steel & Alloys, Ltd.; St. Joseph Elec. Steel Castings Co.; Standard Alloy Co.; Wm. J. Sweet Foundry Co.; Symington Co.; Taylor-Wharton Iron & Steel Co.; Texas Elec. Steel Castings Co.; Warman Steel Casting Co., Ltd.; Washington Iron Works; West Steel Casting Co.

Licenses Meehanite Metal Corp., Chattanooga, Tenn. — American Laundry Machine Co., Rochester, N. Y.; H. W. Butterworth & Sons, Bethayres, Pa.; Banner Iron Works St. Louis, Mo.; Dodge Manufacturing Co., Toronto, Canada; Dayton Malleable Iron Co., Dayton, Ohio; Fulton Foundry & Machine Co., Cleveland, Ohio; Farrel-Birmingham Co., Ansonia, Conn.; G. H. R. Foundry Co., Dayton, Ohio; Greenlee Foundry Co., Chicago, Ill.; Hamilton Foundry & Machine Co., Hamilton, Ohio; Kinney Iron Works, Los Angeles, Calif.; Koehring Co., Milwaukee, Wis.; Michigan Valve & Foundry Co., Detroit, Mich.; Pratt & Letchworth Co., Buffalo, N. Y.; Rosedale Foundry & Machine Co., Pittsburgh, Pa.; Ross-Meehan Foundries Co., Chattanooga, Tenn.; Trenton Malleable Iron Co., Trenton, N. J.; Vulcan Foundry Co., Oakland, Calif.; West Coast Meehanite Metal Corp., Los Angeles, Calif.; Kanawha Manufacturing Co., Charleston.

NON-METALLIC MATERIALS

MATERIAL	MANUFACTURER (Name and Address)	Composition and Applications
RUBBER PRODUCTS		
ACE	American Hard Rubber Co., New York, N. Y.	Hard and soft rubber linings and shapes; rubber fittings
ACE	American Hard Rubber Co., New York, N. Y.	Rubber paint
ACIDSEAL	B. F. Goodrich Co., Akron, Ohio	Rubber paint
ARMORITE	B. F. Goodrich Co., Akron, Ohio	Abraison-resistant lining
CONDOR	Manhattan Rubber Mfg. Co., Passaic, N. J.	Belts, brake linings, blocks, hose, rolls, pipe
DELHI	Manhattan Rubber Mfg. Co., Passaic, N. J.	Belts, hose
DUPRENE	E. I. du Pont de Nemours & Co., Wilmington, Del.	Synthetic rubber
ECONOMY	Manhattan Rubber Mfg. Co., Passaic, N. J.	Fire hose
FIRE KING	B. F. Goodrich Co., Akron, Ohio	Welding hose
GOLDEN PLY	B. F. Goodrich Co., Akron	Hot-material belting
GOODRICH	B. F. Goodrich Co., Akron	Steam hose
HERCULES	American Hard Rubber Co., New York, N. Y.	Rubber pails
MANHATTAN	Manhattan Rubber Mfg. Co., Passaic, N. J.	Belts, hose, rolls, linings
MASTER	Manhattan Rubber Mfg. Co., Passaic, N. J.	Belts
PAROCK	Manhattan Rubber Mfg. Co., Passaic, N. J.	Oilless bearings
PILOT	U. S. Rubber Co., New York	Rubber-lined pipe
SUPER-HEAT	B. F. Goodrich Co., Akron	Sheet packing
THIOLKOL	Thiokol Corp., Yardville, N. J.	Olefin polysulphide reaction product
U. S. PERMOBOND DUROLINE	U. S. Rubber Co., New York, N. Y.	Semi-hard lining
U. S. PERMOBOND GUMLINE	U. S. Rubber Co., New York, N. Y.	Unvulcanized, for wooden tanks
U. S. PERMOBOND KHEMLINE	U. S. Rubber Co., New York, N. Y.	Soft, general service lining
U. S. PERMOBOND KLEERLINE	U. S. Rubber Co., New York, N. Y.	Soft, non-corrosive
U. S. PERMOBOND TUFFLINE	U. S. Rubber Co., New York, N. Y.	Hard, wear resisting
VULCALOCK	B. F. Goodrich Co., Akron	Rubber linings

GLASS AND FUSED SILICA

PYREX	Corning Glass Works, Corn- ing, N. Y.	Borosilicate glass
VITREOSIL	The Thermal Syndicate, Brooklyn, N. Y.	SiO ₂ , 99.8 +
FUSED QUARTZ	Hanovia Chemical & Mfg. Co., Newark, N. J.	Transparent fused quartz
FUSED QUARTZ	General Electric Co., Schene- ctady, N. Y.	Transparent fused quartz
AMERSIL	Amersil Corp., Hillside, N. J.	Fused silica ware

GLASS-LINED EQUIPMENT

PFAUDLER	The Pfaudler Co., Rochester, N. Y.	Glass-lined steel
GLASCOTE	Glascote Co., Euclid, Ohio	Enamel-lined steel
METAL-GLASS	Metal-Glass Products Co., Belding, Michigan	Enamel-lined steel

MATERIAL	MANUFACTURER (Name and Address)	Composition and Applications
CHEMICAL STONEWARE		
ACITHERM	U. S. Stoneware Co., New York, N. Y.	Heat and acid-resistant ceramics
CHEMICAL STONEWARE	General Ceramics Co., New York, N. Y.	Chemical Stoneware, SiO ₂ , 73.2; Al ₂ O ₃ , 22.3
KNIGHT-WARE	Maurice A. Knight, Akron, Ohio	Aluminum silicate

PLASTICS

BAKELITE	Bakelite Corp., Bloomfield, N. J.	Phenolic resinoid
BEETLE	Synthetic Plastics Co., New York, N. Y.	Urea resinoid
CATALIN	American Catalin Corp., New York, N. Y.	Cast phenolic
CELORON	Continental Diamond Fibre Co., Newark, Del.	Phenolic resinoid
CETEX	General Electric Co., Schenectady, N. Y.	Cold-molded plastic
DIELECTO	Continental Diamond Fibre Co., Newark, Del.	Phenolic resinoid
DUREZ 1407	General Plastics, Inc., N. Tonawanda, N. Y.	Phenolic resinoid
DUREZ, WOODFILLED	General Plastics, Inc., N. Tonawanda, N. Y.	Phenolic resinoid
DURITE	Stokes & Smith Co., Philadelphia, Pa.	Phenolic resinoid
FORMICA	Formica Insulation Co., Cincinnati, Ohio	Phenolic resinoid
HAVEG	Haveg Corp., Newark, Del.	Phenolic resinoid
LAMICOID	Mica Insulator Co., Schenectady, N. Y.	Phenolic resinoid
LUMARITH	Celluloid Corp., Newark, N. J.	Cellulose acetate
MICARTA	Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.	Phenolic resinoid
PANELYTE	Panelyte Corp., Trenton, N. J.	Phenolic resinoid
PHENOLITE	Natl. Vulcanized Fibre Co., Wilmington, Del.	Phenolic resinoid
PLASTACELE	Du Pont Viscoid Co., Arlington, N. J.	Cellulose acetate
PLASKON	Toledo Synthetic Products, Inc., Toledo, Ohio	Urea resinoid
PLIOFORM	Goodyear Tire & Rubber Co., Akron, Ohio	Rubber resinoid
PYRALIN	Du Pont Viscoid Co., Arlington, N. J.	Cellulose nitrate
PYROFLEX	Maurice A. Knight, Akron, Ohio	Depolymerized colloidal resin
RESINOX	Resinox Corp., New York, N. Y.	Phenolic resinoid
RESOGLAZ	Advance Solvents & Chem. Co., New York, N. Y.	Styrol resinoid
SPAULDITE	Spaulding Fibre Co., Tonawanda, N. Y.	Phenolic resinoid
SYNTHANE	Synthane Corp., Oaks, Pa.	Phenolic resinoid
TENITE	Tennessee Eastman Corp., Kingsport, Tenn.	Cellulose acetate
TEXTOLITE	General Electric Co., Schenectady, N. Y.	Phenolic resinoid
THIOLKOL	Thiolkol Corp., Yardville, N. J.	Olefine polysulphide reaction product
TORNESIT	Hercules Powder Co., Wilmington, Del.	Chlorinated rubber
UNYTE	Unyte Corp., New York, N. Y.	Urea resinoid
VICTRON	Naugatuck Chemical Co., New York, N. Y.	Styrol resinoid
VINYLLITE	Carbide & Carbon Chem. Co., New York, N. Y.	Vinyl resinoid

VULCANIZED FIBERS

DIAMOND	Continental Diamond Fibre Co., Newark, Del.	
NATIONAL	National Vulcanized Fibre Co., Yorklyn, Del.	
SPAULDING	Spaulding Fibre Co., Rochester, N. H.	
SPAULDING	J. Spaulding & Sons Co., Tonawanda, N. Y.	
WILMINGTON	Wilmington Fibre Specialty Co., Wilmington, Del.	

CARBON

NATIONAL	National Carbon Co., Cleveland, Ohio	Carbon and graphite brick, tile, Raschig rings, pipe, Cottrell precipitators, packing rings, atmospheric coolers, filter plates, ground rods, towershapes.
----------	--------------------------------------	--

MATERIAL	MANUFACTURER (Name and Address)	Composition and Applications
SPEER	Speer Carbon Co. Saint Mary's, Pa.	Carbon and graphite brick plates, blocks, cylinders, tubings, bushings, gaskets, packings, mix for tamped bottoms

ASBESTOS-CEMENT

TRANSITE	Johns-Manville, New York, N. Y.	Sheet, conduits, flues, pressure pipe, ventilators
----------	---------------------------------	--

ACID-PROOF BRICK AND MASONRY

ACIDO	General Refractories Co., Philadelphia, Pa.	SiO ₂ , 61; Al ₂ O ₃ , 31.4
AGO	Alphonse Custodis Chimney Construction Co., New York	Bricks
	Chemical Appliances Inc., New York, N. Y.	Bricks
CUSTODIS MASONRY	Alphonse Custodis Chimney Construction Co., New York	Masonry
DURO	Electro-Chemical Supply & Engr. Co., Paoli, Pa.	Pure clay burned at high temperature
POROX	Patterson Fdry. & Mach. Co., East Liverpool, Ohio	Vitrified blocks, quartz, silica, aluminum base

CEMENTS

(Corrosion, Oil and Water-Resisting)

Manufacturer	Trade Name	Application, etc.
Anti-Hydro Waterproofing Co., Newark, N. J.	Anti-Hydro	Waterproofs concrete mix, giving resistance to acids, alkalis, oils
Atlas Mineral Products Co., Mertatown, Pa.	Minerallead	Sulphur-base cement for cast iron joints
	Vitrobond	Sulphur-base cement for brick and tile
Charlotte Chemical Labs., Charlotte, N. C.	Charlab	Chemical-setting silicate cement for acids, water, and steam
	Acipruf	Silicate cement for strong acids
	Carolina	Premixed silicate cement for strong acids
	Chemical Putty	Water and acid resisting plastic putty
Alphonse Custodis Chimney Construction Co., New York, N. Y.	Penchlor	See Pen-Chlor, Inc.
Electro-Chemical Supply & Engineering Co., Paoli, Pa.	Asplit	
	Duro Standard	Silicate (?) cement for strong acids
	Duro Special	Silicate (?) cement for strong and weak acids
	Duro Triple X	Silicate (?) cement for strong and weak acids, steam and water
General Ceramics Co., New York, N. Y.	Acidproof No. 1	Asbestos-base silicate cement for strong acids
	Acidproof No. 6	Linseed-oil-base (?) putty for glass and stoneware
	Acidproof No. 7	Asphalt-base pouring cement for acids, alkalis and weather resistance
	Acidproof No. 8	Quartz-base silicate cement for strong acids
B. F. Goodrich Rubber Co., Akron, Ohio	Plastikon	Corrosion and water resistant rubber-base putty
The Haveg Corp., Newark, Del.	Havegit 41	Self-hardening phenolic-resin cement for most acids
	Havegit 43	Ditto for HF, fluorides, etc.
Maurice A. Knight, Akron, Ohio		Silicate cement for strong acids
Nukem Products Co., New York, N. Y.	Basolit	Sulphur-silica pouring cement for acids
Patterson Fdry. & Mach. Co., East Liverpool, Ohio	Porox Cement	Silicate cement for strong acids
Peccora Paint Co., Philadelphia, Pa.	Acitite Q.D.	Quick-drying silicate (?) cement for strong acids
	Acitite S.D.	Slow-drying silicate (?) cement for strong acids
	Dry Acitite	Quick-setting cement for acids, water, and steam
	Aciechlor	Elastic putty for acids, alkalis, hydrogen, weatherproofing
Pen-Chlor, Inc., Philadelphia, Pa.	Cushion Putty	Elastic putty for acids
	Penchlor	Chemical-setting silicate cement for acids, water, and steam
	Asplit	Self-hardening phenolic-resin cement for most acids
Philadelphia Quarts Co., Philadelphia, Pa.	"S" Brand Sodium Silicate	Silicate solution of 1:3.86 ratio and 33.1 der. B _é .
Quigley Co., Inc., New York, N. Y.	Acidproof No. 1	Premixed silicate cement for hot acid gases
	Acidproof No. 2	Premixed silicate cement, water-tight, for mineral acids
H. H. Robertson Co., Pittsburgh, Pa.	Asphaltic Fibre Putty	Plastic caulking compound for acids, alkalis and weather resistance
The Sullivan Co., Memphis, Tenn.	Acidol	Sulphur-base (?) pouring cement for acids and alkalis
	Sulsilo	Premixed silicate cement for strong acids
Technical Products Co., Pittsburgh, Pa.	Insa-Lute No. 1	Premixed silicate cement for acids and high adhesion
	Acidproof No. 10	Premixed silicate cement for acids
	Acidproof No. 21	Quick-setting silicate (?) cement for mixing with water
	Acidproof No. 22	Quick-setting cement for acids, for mixing with silicate (?) binder
	Plastic Iron Cement	Resistance to heat, water, oils, alkalis
	Melting Compound No. 49	Resistance to acids, alkalis, water, oils
U. S. Stoneware Co., Akron, Ohio	U. S. Standard	Silicate cement for strong acids
	Vitric-10	Chemical-setting silicate cement for acids, steam, and water
	Vitric-15	Chemical-setting silicate cement for strong and weak acids
	Pre-Mixt	Premixed chemical-setting silicate cement for acids, steam, and water
	Portite	Sulphur-base pouring cement for acids
	Duralute	Resin-base pouring cement for acids and alkalis
	Calctite	Asphaltic-base pouring cement for acids

News of the INDUSTRY

Electrochemists Hold Successful Meeting

THE sixty-sixth semi-annual meeting of the Electrochemical Society was held in New York, Sept. 27-29. Three hundred and fifty members and guests took part in one of the most successful conventions the Society has ever had.

Several of the papers that were presented at the technical sessions presided over by President Hiram S. Lukens, James H. Critchett and Dr. D. A. MacInnes attracted unusual attention. These will be reported upon in the November issue of *Chem. & Met.*

The Society honored Dr. Frederick M. Becket, president of the Union Carbide & Carbon Research Laboratories, at the dinner on Thursday evening at the Hotel Ambassador, by presenting him with honorary membership. At the same affair Samuel G. Hibben, director of applied lighting for the Westinghouse Lamp Co., entertained the guests with an interesting address on color symphony. He stated, "Color lighting, produced through the vapors of certain metals and gases, promises to extend its use beyond that of an aid to vision and to give greater assistance to the research scientists in the fields of medicine, disease prevention, and photography of astronomical bodies." Following Dr. Hibben's address Miss Lillian Moore of the Metropolitan Opera ballet and a daughter of W. C. Moore entertained with several solo dances.

The young engineers' luncheon on Saturday was under the supervision of Dr. Charles F. Bonilla. S. D. Kirkpatrick, editor of *Chem. & Met.*, presided. Brief talks were made by leaders in the various divisions of electrochemistry, including Dr. Becket, Dr. L. D. Vorce, inventor of the Vorce cell, Dr. O. H. Caldwell, editor of *Electronics*, and Dr. Frank B. Jewett, president of the Bell Telephone Laboratories.

Arrangements were made for inspecting several industrial plants in metropolitan New York. On Thursday visits were made to the Bell Telephone

Laboratories, Philip Sievering, Inc., and the General Electric Vapor Lamp Co.'s Hoboken plant. The following day the Keasbey, N. J., plant of the General Ceramics Co., the hydrogenation plant of the Standard Oil Co. of New Jersey, the Bloomfield works of the Westinghouse Lamp Co. At Kearny, N. J., the new mercury vapor boiler and generator in a station of the Public Service Electric and Gas Co. was inspected.

The committee of arrangements for the convention was headed by James A. Lee, managing editor of *Chem. & Met.*, and W. W. Winship, manager of Thermal Syndicate, Ltd. The next meeting of the Society will be held in New Orleans, March 21-23.

Specifications for Alloys Approved by A.S.T.M.

ON THE recommendation of its Committee A-1 on Steel, the American Society for Testing Materials has accepted for publication as tentative two specifications covering (a) alloy-steel castings for valves, flanges and fittings and (b) seamless alloy-steel pipe, the materials being for service at temperatures from 750 to 1,100 F. There have been urgent demands from industry for these specifications.

The specifications for alloy-steel castings, designated (A 157-34 T) include eight classes of materials, six ferritic steels and two austenitic steels. The seamless alloy-steel pipe specifications (A 158-34 T) cover eight ferritic and four austenitic steels. The specifications, which were drafted by subgroups headed by Prof. A. E. White, University of Michigan and N. L. Mochel, Westinghouse Electric and Manufacturing Co., provide that information on high-temperature data is to be a matter of agreement between the purchaser and seller until such time as the committee's studies warrant the addition of an appendix giving data now being developed.

The Society also approved for publi-

cation as tentative three specifications covering (a) copper-silicon alloy plates and sheets (B 96-34 T); (b) sheet copper-silicon alloy (B 97-34 T); (c) copper-silicon alloy rods, bars and shapes (B 98-34 T). The committee has been working on these for some time in view of the increasing requests from various sources for standardized requirements.

The three specifications have the same chemical composition requirements. This involves a silicon range of from 1 to 5 per cent and the following maximum percentages of the respective metals: Manganese, 1.50; zinc, 5.00; iron, 2.50; tin, 2.00; aluminum, 2.00; with copper the remainder. In the case of the specifications for sheets which are commonly used for drawing, forming, stamping and bending, the minimum tensile strength requirement in the case of soft material is 50,000 lb. per sq.in., with an elongation of 35 per cent in 2 in.

Price Filing Proposed for Anti-Freeze Methanol

ON Sept. 27, M. H. Haertel, secretary of the hardwood distillation industry's code authority, submitted a proposal to amend the code so as to include filing of prices. The proposed amendment would apply only to methanol sold for anti-freeze purposes. The provisions include:

"Inasmuch as the supplementary code of fair competition for the industrial alcohol industry, a division of the chemical manufacturing industry, has a similar provision for the filing of prices of ethyl alcohol, isopropyl alcohol, and methyl alcohol (other than that produced from the destructive distillation of wood), prices filed under said code and under this article shall be exchanged under the same conditions as outlined above in so far as they apply to such alcohols when sold for anti-freeze purposes.

"There shall be collected in the manner described in Article VII of this code, statistics concerning anti-freeze methanol. These statistics shall be interchanged with corresponding figures gathered by the industrial alcohol industry."

Hercules Plans Domestic Tornesit Production

OFFICIALS of Hercules Powder Co. announced early in the month that work will begin shortly on a new plant at Parlin, N. J., for the manufacture of tornesit, the company's new protective coating material. With the opening of this plant, tornesit will be produced in this country for the first time, replacing the material now being imported from Germany.

Program Announced for A.I.Ch.E. Meeting

THE American Institute of Chemical Engineers will hold its 27th annual meeting in Pittsburgh, Nov. 14 to 17. Headquarters will be in the Hotel Schenley. Extensive plans have been made for an interesting program by the local committee, which is headed by Dr. Webster N. Jones, Director of the College of Engineering at the Carnegie Institute of Technology. The conference will open with a council meeting on Wednesday evening, Nov. 14. For the same evening a lecture on a scientific subject with popular appeal has been scheduled.

General registration will start Thursday morning, and the technical sessions will begin at 10 a.m. of that day and will run until noon. On Friday morning two parallel sessions have been planned; one will be devoted to principles, the other to practical applications of chemical engineering. On Saturday morning another technical session will be held. Upper class students in chemical engineering from the University of Pittsburgh and the Carnegie Institute of Technology have been invited to attend all technical sessions.

Chemical industries in the Pittsburgh district offer unusual opportunity for the delegates to see new and interesting technical processes, and the committee has not overlooked this feature in planning the program.

Permission has been obtained to go through the Micarta plant of the Westinghouse Co. and in its research laboratory a demonstration of various phases of the high tension work is to be held. The laboratories of the Aluminum Co. of America at New Kensington will be of particular interest as well as the fabrication of a multitude of aluminum articles, including the spinning of large vessels and cold rolling of pipe. Automatic large scale welding equipment and continuous pipe manufacture of the latest type are to be seen in operation at the National Tube and the Byers company. The St. Joseph Lead Co. plant includes the roasting of zinc blend, a contact sulphuric acid plant, and the manufacture of zinc oxide by the electric furnace process. The Davison Coke and Iron Co. has a small Koppers installation, including blast furnace and wet and dry process gas purification. The Mine Safety Appliance Co. is of varied interest in the manufacture of first aid specialties, dust and gas masks, miners' helmets, and the molding of rubber parts.

On Thursday and Friday afternoons members will have an opportunity to visit the new Mellon Institute, the Chemical Engineering and the Coal Research Laboratories at Carnegie Insti-

tute of Technology, and the Department of Chemical Engineering at the University of Pittsburgh. The U. S. Bureau of Mines and the Gulf Research Laboratory will also be open for visitors.

On Thursday evening delegates and their friends will be guests of the Carnegie Institute of Technology at a play, "Glass Houses," in the Little Theatre of the College of Fine Arts. The play will be produced by students in the department of drama.

The formal occasion of the meeting and outstanding social event will be a dinner and dance at the University Club. The speaker at the banquet will be Arthur Brisbane, famous journalist.

At the time of writing the tentative list of papers is as follows:

"Some New Sulphur Cements," Werner W. Duecker, Senior Fellow, Mellon Institute of Industrial Research; "Some Polar Characteristics of Electrical Insulation," C. F. Hill, Insulation Section, Research Laboratories, Westinghouse Electric and Mfg. Co.; "The Alcohols of Industry," E. W. Reid, Mellon Institute of Industrial Research; "Inductively Heating Process Equipment," Robert D. Center, chemical engineer, Buffalo; "The Use of Aluminum in the Chemical Industry," Francis C. Frary, Director of Research, Aluminum Co. of America; "Refractories and Their Application," W. F. Rochow, technical department, Harbison-Walker Refractories Co.; "Application of Photography to Chemical Engineering Research," Dr. Walter Clark, Eastman Kodak Co.; "Heat Losses in Furnaces," R. H. Heilman, Mellon Institute of Industrial Research; "Removal of Ice From Aeroplanes in Flight" (lecture only), W. C. Geer, Ithaca, N. Y.; "Sulphuric Acid by the Chamber Process," Ernst Berl, Carnegie Institute of Technology; "Heat Transfer by Radiation," H. C. Hottel, Massachusetts Institute of Technology; "Agitation," Columbia University contribution, headed by Dr. A. W. Hixson; "Heat Transfer and Pressure Drop Data for Oil in a Copper Tube," J. F. Downie Smith, Department of Mechanical Engineering, Harvard Engineering School; "The Enthalpy-Concentration Chart—Part I, Applications; Part II, Theory of the Chart and Construction of Chart for Solutions of Sodium Hydroxide in Water," Warren L. McCabe, Department of Chemical Engineering, University of Michigan.

For the ladies, a special program of entertainment has been arranged, beginning Thursday morning with a trip to the Heinz plant, followed by a luncheon. That afternoon the ladies will visit the International Art Exhibit, at the Carnegie Museum, and the Phipps Conservatory. On Friday the main attraction will be the National Chrysanthemum Show, which is to be held simultaneously at the Syria Mosque.

Safety Council Sessions Well Attended

BEST attended and most representative of chemical industries were the sessions of the National Safety Council, held in Cleveland, Oct. 1-5. Professor W. R. Veazey, head of chemical engineering at Case, opened the meeting of the Chemical Section with well pointed words of advice as well as welcome. He showed how the chemical engineer must be concerned more with men than with things and machines. Chairman John Roach, deputy commissioner of labor in New Jersey, presided and led discussion of papers presented by A. L. Armstrong of Eastman Kodak, A. C. White of the Dow Chemical Co., F. J. O'Connor and H. P. Lewis, of the du Pont company, Alfred Vaksdal of Corning Glass Works, and S. D. Kirkpatrick of *Chem. & Met.*

In the absence of John S. Shaw of Hercules, M. J. Crass, of Grasselli, presided at a subject session on "Safe Use of Chemicals in Industry," in which papers were presented by E. J. Smith of Western Electric, Dr. C. P. Fordyce of Merck, and Stanley Warzala of Calco.

Newly elected officers for the Chemical Section of the National Safety Council, Inc., are as follows: general chairman, A. L. Armstrong, Eastman Kodak Co.; vice chairman in charge of program: H. L. Miner, E. I. duPont de Nemours & Co., Wilmington, Del.; vice chairman in charge of engineering: C. L. Jones, Safety Engineer, Hercules Powder Co., Wilmington, Del.; secretary: Ralph O. Keefer, Aluminum Company of America, Massena, N. Y.; news letter editor: E. L. Root, Celluloid Corp., Newark, N. J.; occupational disease committee chairman: Dr. Leonard Greenburg, Yale Medical School, New Haven, Conn.; membership and publicity committee chairman, S. D. Kirkpatrick, *Chem. & Met.*; statistics committee chairman: R. C. Stratton, The Travelers Insurance Co.; members at large of executive committee: F. E. Clancy, Jr., Mathieson Alkali Works, Inc., Niagara Falls, N. Y.; F. W. Dennis, Hooker Electrochemical Co., Niagara Falls; Ira V. Kepner, Pennsylvania Salt Mfg. Co., Menominee, Mich.; E. F. King, Lever Bros. Co., Cambridge, Mass.; H. P. Lewis, E. I. duPont de Nemours & Co., Wilmington, Del.; John Roach, Deputy Com. of Labor, Trenton, N. J.; C. E. Sevens, Merriam Chem. Co., Inc., Boston, Mass.; Plummer Wheeler, American Cyanamid Co., Linden, N. J.; S. E. Whiting, Liberty Mutual Insurance Co., Boston, Mass.

The Chemical Section passed a resolution suggesting the next meeting be held in New Jersey because of the prominence of the industry in that state.

NO BROAD issue was involved on complaint of Allied Chemical Workers, Local No. 18705, against National Aniline & Chemical Co., Buffalo, but the National Labor Relations Board held that the terms to which a company assents must be embodied in an agreement binding upon both parties for a definite period of time. The company contended that by conferring with the union's committee and subsequently posting the terms on which it was willing to act, it had done all it was required to do under the statute.

The board did not attribute to the company an intention to deny the rights of its employees to collective bargaining but said that by delaying negotiations and adhering to a narrow and legalistic reading of its duties under Section 7a the company has weakened the position of the union. The collective bargaining provision would be empty of significance, said the board, if it did not contemplate embodiment of mutually satisfactory terms in a legally valid agreement.

The board held that such an agreement need not necessarily be reduced to writing but pointed out that in this case there was a dispute as to whether the plant notice correctly embodied the terms which the company had indicated were acceptable to it in conferences with the employees' representatives. In cases such as this, the agreement, unless reduced to writing, will be so impractical of enforcement and so fruitful of disputes concerning terms, said the board, that insistence by an employer that he will go no further than to enter into an oral agreement may be evidence, in the light of other circumstances in the case, of a denial of the right of collective bargaining.

Producers and distributors of corn sugar, yeast and other ingredients of distilled liquor now required by law to keep a record of sales and shipments are cooperating with the Government in this method of suppressing illicit stills and tax evasion. The industries affected believe, according to the Alcohol Tax Division of the Treasury Dept., that the law will have a wholesome effect on their business as they expect to recoup in larger sales through legitimate channels any falling off in business that originates in and now can be traced back to the bootleg trade.

The regulations under which it becomes mandatory on all manufacturers of materials used in manufacture of distilled spirits to keep records for inspection and for furnishing sworn reports on request by the Commissioner of Internal Revenue were not issued until Sept. 11 but by agreement with the Alcohol Tax Unit, the manufacturers have been submitting such records ever since the Doughton resolution was

NEWS FROM WASHINGTON

By PAUL WOOTON

*Washington Correspondent
of Chem. & Met.*



enacted last June. Supplied with this vast mass of information for tracing the raw materials through their several and frequently tortuous channels of distribution, the tax unit is seizing a large number of stills.

A close check on shipments of corn sugar apparently is forcing illicit distillers to shift to the use of cane sugar, a more expensive and longer operation. Sales of such alternative materials, including blackstrap molasses, beet and cane sugar, together with yeast and oak chips, also are being checked as the Government closes in on the sources of supply previously available in large quantities on the open market, without restriction.

The regulations with which producers and distributors now must comply under penalty of a \$500 fine, one year's imprisonment or both, exempt sales of small quantities commonly entering legitimate trade. Unless specifically instructed to do so by the Commissioner or district supervisor or the alcohol tax unit, the manufacturer or distributor need not keep records, invoices, bills of lading and other information when sales do not exceed the following: 300 lb. of cane, corn, or beet sugar; 200 gal. of blackstrap; or 5 lb. of yeast, when packaged or cartoned in $\frac{1}{4}$ lb., $\frac{1}{2}$ lb., 1 lb. or larger units.

Paint Industry Favored

Officials of the Federal Housing Administration express the opinion that the paint industry promises to benefit as much as any other single activity from the remodeling program. Few repairs or betterments can be made in dwellings or business buildings without the use of paint as a necessary material in finishing off the repairs. While that phase of the work promises to consume material quantities of paint, the real opportunity for the paint industry, housing officials point out, is in cooperating with the local administration committees in per-

suading home and store owners to paint up.

Never before, it is contended, has it been so easy for the home owner to pay for his paint and the labor involved on the installment plan, or what amounts to an installment plan in so far as the owner of the property is concerned. The dealer receives spot cash but the owner may have as much as three years in which to repay the necessary loan. It is argued that since the automobile industry, the radio industry and many others have been built on installment selling, that the paint industry, as well as cement producers, lumber manufacturers and paper hangers, should recognize that the government has brought to them the benefits of the installment plan without the need of organizing finance companies or extending any credit themselves.

While a great deal of help can be extended by the voluntary committees which the Housing Administration has set up in every community, it is realized that the needed persistent sales effort necessary to the acquisition to the maximum amount of business must come from those who have an opportunity to profit. Every house in need of repainting should stand, it is declared, as a challenge to the local housing committee and the local paint dealers. They are expected to concentrate on those properties until they have been painted or until it is established that the case is hopeless.

Sample surveys that have been made have developed that few systematic efforts have been made to sell the cleanup, paintup idea. Large numbers of those interviewed stated that no one during the entire depression had called to inquire as to the possibility of doing painting or other betterment work.

The Housing Administration is carrying its campaign a step further. As rapidly as possible its representatives will call on every manufacturer of paint and of other materials used in construction to determine whether as beneficiaries of the housing program they have done their part toward stimulating the capital goods industries by modernizing their equipment or repairing and burnishing up their own buildings. The whole housing program is an effort to stimulate the durable goods industries. For that reason Housing Administrator Moffett and his assistants believe that they are entitled to active help from these industries and the stimulation which will follow if they set a good example by modernizing their own properties.

In connection with the housing program it is pointed out that landscaping is an important feature in which the fertilizer industry should have an active interest.

The MARKETS

INTEREST in chemicals has increased in the last month and this has been indicated not only by the greater regularity with which shipping instructions have been received for contract deliveries but also by a larger and more diversified buying in the spot market. Prices have been somewhat irregular with many fluctuations reported on both sides of the market. Accumulations of stocks brought out a downward revision in the quotation for acetate of lime and this was followed by a lower sales schedule for all grades of acetic acid. On the other side of the market, higher prices became effective on phosphates of soda and a firm tone was noted in the list of solvents with a rise in values announced for butyl alcohol and butyl acetate and with a sharply rising trend for spirits of turpentine in the closing days of the period.

Considerable interest has been aroused by discussions regarding the probable effect that production of alkalis in the new plants, now in operation or in process of building, will have upon the price stability of that market. Some of the large consuming trades have interpreted the establishment of new production as proof that over-production would result and prices for 1935 deliveries would be lowered as a result of the selling competition which would come into existence. Producers, however, dissipated such ideas by announcing that existing contract prices would be continued for next year and chlorine contract prices

were advanced from \$1.85 per 100 lb. to \$2.00 per 100 lb.

Domestic Potash Exports

Competition in the market for potash salts remains keen with large stocks of foreign material reported to be held in store in this country. While the United States is one of the world's largest importers of fertilizers and fertilizer materials, it is able as a result of certain transportation advantages to export substantial quantities of potash salts, according to the Commerce Department's statistics. During the first half of 1934, United States exports of potash amounted to 15,840 tons, valued at \$627,000, compared with 25,080 tons, valued at \$902,000, for the whole of 1933 and 1,816 tons, valued at \$70,000, for the calendar year 1932. In addition 6,440 tons were shipped to Hawaii and 6,350 to Puerto Rico during the first half of 1934.

Japan, the largest foreign purchaser of American potash fertilizers, took 12,705 tons of the 1934 shipments valued at \$502,500, or approximately 80 per cent of total shipments abroad. During the calendar year 1933 Japan purchased 16,920 tons and in 1932 only 1,050 tons. Other countries purchasing American potash fertilizer in 1934 included Canada, generally the second largest foreign customer, Cuba and the Philippine Islands.

Approximately 71 per cent of all United States export shipments since the beginning of 1934 went from Los Angeles, 13 per cent from Galveston, 6½ per cent from Michigan, with smaller consignments from Oregon, Michigan, Maryland, and New York.

Sales of paint, varnish, and lacquer have shown improvement and the outlook is regarded as very promising for a continued increase for the coming month. Sales for the first eight months of this year were valued at \$199,629,469. Sales for the 12 months of 1933 and 1932 were valued at \$222,760,965 and \$203,323,315 respectively.

Latest available figures for production of methanol refer to the month of July and emphasize the dominant position the synthetic product holds in that

market. Production for the first seven months of this year was reported at 2,285,528 gal. for crude methanol and 6,101,783 gal. for the synthetic material.

Turpentine and rosin, which were marked by sharp price advances in the last week, are in a stronger position, as far as holding stocks off the market is concerned, by virtue of an announcement made on Oct. 5 which informed the trade that the board of directors of the Commodity Credit Corporation had approved an increase in the net loan value per unit on gum turpentine and gum rosin from \$40 to \$50, as recommended by the Agricultural Adjustment Administration. New loan document forms are to be printed and distributed as soon as details are completed. The loans are to be made under plans similar to those now in effect and are to be financed out of the original \$6,000,000 commitment made to the Commodity Credit Corporation by the Reconstruction Finance Corporation for that purpose.

On Sept. 25, the A.A.A. announced establishment of a processing tax of 1c. a lb. on farmers' stock weight on peanuts to become effective Oct. 1.

Exports of leading chemicals and allied products during the first eight months of the current year were valued at \$75,000,000, an increase of almost 25 per cent over the corresponding period of 1933 according to preliminary figures. Industrial chemicals led the list with a 40 per cent increase to \$14,000,000; followed by naval stores, gums, and resins which increased 5 per cent to \$10,000,000; paint products increased 32 per cent to \$9,200,000; and coal tar products, including dyes, which advanced 20 per cent to \$9,150,000. Exports of fertilizer and fertilizer materials advanced from \$4,400,000 to \$7,600,000, an increase of 71 per cent, due largely to increased foreign demand for American phosphate rock. Other important items on the chemical export list which registered gains included sulphur, 8 per cent; medicinal and pharmaceutical products, 12 per cent; chemical specialties, 16½ per cent; and soaps and toilet preparations, 24 per cent.

CHEM. & MET. Weighted Index of CHEMICAL PRICES

Base = 100 for 1927

This month	87.71
Last month	87.51
October, 1933	86.05
October, 1932	84.63

Price changes were numerous with declines in quotations for acetate of lime, acetic acid, arsenic, and caustic potash. Higher prices were in effect for acetone, butyl alcohol and acetate, phosphate of soda, and naval stores.

CHEM. & MET. Weighted Index of Prices for OILS AND FATS

Base = 100 for 1927

This month	74.02
Last month	68.65
October, 1933	53.07
October, 1932	44.51

With the exception of linseed and China wood oils, the upward swing to prices was continued in the market for vegetable oils and animal fats. Cottonseed oil led in the price movement although tallow and animal fats advanced sharply.

Current PRICES

The following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to Oct. 13.

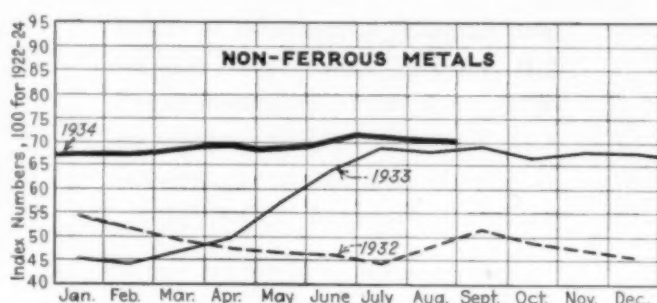
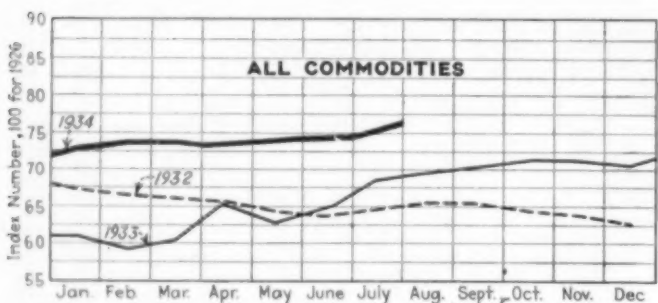
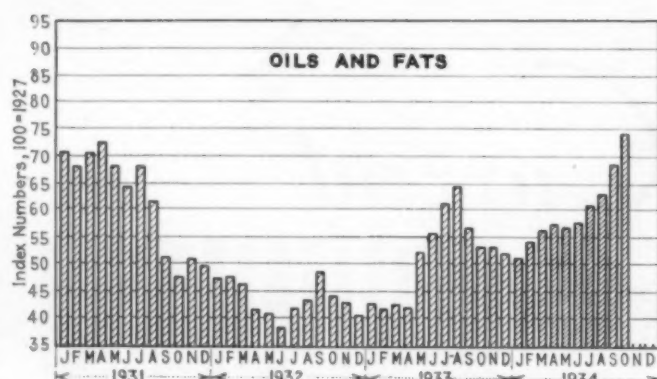
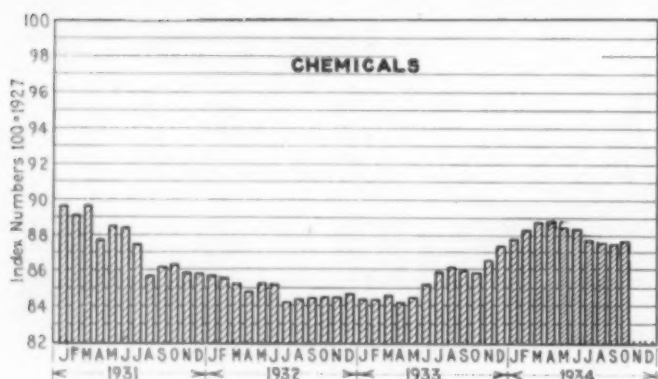
Industrial Chemicals

	Current Price	Last Month	Last Year
Acetone, drums, lb.	\$0.12 - \$0.12	\$0.11 - \$0.11	\$0.10 - \$0.10
Acid, acetic, 28%, bbl., cwt.	2.53 - 2.67	2.76 - 2.90	2.90 - 3.15
Glacial 99%, drums.	8.69 - 8.94	9.13 - 9.38	10.02 - 10.27
U. S. P. reagent, c'ys.	10.52 - 10.77	10.52 - 10.77	10.52 - 10.77
Boric, bbl., lb.	.041 - .05	.041 - .05	.041 - .05
Citric, kegs, lb.	.28 - .31	.28 - .31	.29 - .31
Formic, bbl., lb.	.11 - .11	.11 - .11	.11 - .11
Gallie, tech., bbl., lb.	.60 - .65	.60 - .65	.60 - .65
Hydrofluoric 30% carb., lb.	.07 - .07	.07 - .07	.07 - .07
Latic, 44%, tech., light, bbl., lb.	.12 - .12	.12 - .12	.11 - .12
22%, tech., light, bbl., lb.	.06 - .07	.06 - .07	.05 - .06
Muriatic, 18% tanks, cwt.	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Nitric, 36% carboys, lb.	.05 - .05	.05 - .05	.05 - .05
Oleum, tanks, wks. ton.	18.50 - 20.00	18.50 - 20.00	18.50 - 20.00
Oxalic, crystals, bbl., lb.	.11 - .12	.11 - .12	.11 - .12
Phosphoric, tech., c'ys., lb.	.09 - .10	.09 - .10	.09 - .10
Sulphuric, 60% tanks, ton.	11.00 - 11.50	11.00 - 11.50	11.00 - 11.50
Sulphuric, 66% tanks, ton.	15.50 - 15.50	15.50 - 15.50	15.50 - 15.50
Tannic, tech., bbl., lb.	.23 - .35	.23 - .35	.23 - .35
Tartaric, powd., bbl., lb.	.25 - .26	.25 - .25	.24 - .25
Tungstic, bbl., lb.	1.40 - 1.50	1.40 - 1.50	1.40 - 1.50
Alcohol, Amyl.			
From Pentane, tanks, lb.	.143 - .143	.143 - .143	.15 - .15
Alcohol, Butyl, tanks, lb.	.105 - .105	.095 - .095	.095 - .095
Alcohol, Ethyl, 190 p.f., bbl., gal.	4.15 - 4.15	4.15 - 4.15	2.53 - 2.53
Denatured, 190 proof.			
No. 1 special, dr., gal.	.346 - .346	.346 - .346	.33 - .33
No. 5, 188 proof, dr., gal.	.34 - .34	.34 - .34	.34 - .34
Alum, ammonia, lump, bbl., lb.	.03 - .04	.03 - .04	.03 - .04
Chrome, bbl., lb.	.044 - .05	.044 - .05	.044 - .05
Potash, lump, bbl., lb.	.03 - .04	.03 - .04	.03 - .04
Aluminum sulphate, com., bags cwt.	1.35 - 1.50	1.35 - 1.50	1.25 - 1.40
Iron free, bg., cwt.	1.90 - 2.00	1.90 - 2.00	1.90 - 2.00
Aqua ammonia, 26%, drums lb.	.021 - .03	.021 - .03	.021 - .03
tanks, lb.	.021 - .021	.021 - .021	.021 - .021
Ammonia, anhydrous, cyl., lb.	.15 - .16	.15 - .16	.15 - .15
tanks, lb.	.04 - .04	.04 - .04	.05 - .05
Ammonium carbonate, powd tech., casks, lb.	.08 - .12	.08 - .12	.08 - .12
Sulphate, wks., cwt.	1.20 - 1.20	1.20 - 1.20	1.20 - 1.20
Amylacetate tech., tanks, lb., gal.	.142 - .142	.142 - .142	.145 - .145
Antimony Oxide, bbl., lb.	.071 - .08	.08 - .09	.08 - .09
Arsenic, white, powd., bbl., lb.	.031 - .04	.04 - .04	.04 - .04
Red, powd., kegs, lb.	.15 - .15	.15 - .15	.14 - .15
Barium carbonate, bbl., ton.	56.50 - 58.00	56.50 - 58.00	56.50 - 58.00
Chloride, bbl., ton.	74.00 - 75.00	74.00 - 75.00	61.50 - 63.50
Nitrate, cask, lb.	.081 - .09	.081 - .09	.071 - .07
Blanc fixe, dry, bbl., lb.	.031 - .04	.031 - .04	.031 - .04
Bleaching powder, f.o.b., wks. drums, cwt.	1.85 - 2.00	1.85 - 2.00	1.75 - 2.00
Borax, grain, bags, ton.	40.00 - 45.00	40.00 - 45.00	40.00 - 45.00
Bromine, cs., lb.	.36 - .38	.36 - .38	.36 - .38
Calcium acetate, bags.	2.25 - 2.50	2.50 - 2.50	3.00 - 3.00
Arsenate, dr., lb.	.05 - .07	.05 - .07	.07 - .08
Carbide drums, lb.	.05 - .06	.05 - .06	.05 - .06
Chloride, fused, dr., wks. ton.	17.50 - 17.50	17.50 - 17.50	17.50 - 17.50
flake, dr., wks. ton.	19.50 - 19.50	19.50 - 19.50	19.50 - 19.50
Phosphate, bbl., lb.	.071 - .08	.071 - .08	.071 - .08
Carbon bisulphide, drums, lb.	.051 - .08	.051 - .06	.051 - .06
Tetrachloride drums, lb.	.051 - .08	.051 - .06	.051 - .06
Chlorine, liquid, tanks, wks., lb.	.0185 - .0185	.0185 - .0185	.01 - .01
Cylinders.	.051 - .06	.051 - .06	.051 - .06
Cobalt oxide, cans, lb.	1.25 - 1.30	1.25 - 1.30	1.15 - 1.25

	Current Price	Last Month	Last Year
Copperas, bgs., f.o.b. wks., ton.	14.00 - 15.00	14.00 - 15.00	14.00 - 15.00
Copper carbonate, bbl., lb.	.081 - .16	.081 - .16	.081 - .16
Cyanide, tech., bbl., lb.	.37 - .38	.37 - .38	.39 - .44
Sulphate, bbl., cwt.	3.85 - 4.00	3.85 - 4.00	3.75 - 4.00
Cream of tartar, bbl., lb.	.181 - .19	.181 - .19	.171 - .18
Diethylene glycol, dr., lb.	.14 - .16	.14 - .16	.14 - .16
Epsom salt, dom., tech., bbl., cwt.	2.10 - 2.15	2.10 - 2.15	2.10 - 2.15
Imp., tech., bags, cwt.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Ethyl acetate, drums, lb.	.081 - .081	.081 - .081	.081 - .081
Formaldehyde, 40%, bbl., lb.	.06 - .07	.06 - .07	.06 - .07
Furfural, dr., contract, lb.	.10 - .17	.10 - .17	.10 - .17
Fusel oil, crude, drums, gal.	.75 - .75	.75 - .75	.75 - .75
Refined, dr., gal.	1.25 - 1.30	1.25 - 1.30	1.25 - 1.30
Glaucous salt, bags, cwt.	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Glycerine, c.p., drums, extra, lb.	.14 - .14	.13 - .14	.10 - .10
Lead:			
White, basic carbonate, dry casks, lb.	.061 - .061	.061 - .061	.061 - .061
White, basic sulphate, csk., lb.	.06 - .06	.06 - .06	.06 - .06
Red, dry, csk., lb.	.061 - .061	.061 - .061	.08 - .08
Lead acetate, white crys., bbl., lb.	.101 - .11	.101 - .11	.101 - .11
Lead arsenate, powd., bbl., lb.	.07 - .09	.07 - .09	.10 - .13
Lime, chem., bulk, ton.	8.50 - 8.50	8.50 - 8.50	8.50 - 8.50
Litharge, powd., csk, lb.	.051 - .051	.051 - .051	.07 - .07
Lithophone, bags, lb.	.04 - .05	.04 - .05	.04 - .05
Magnesium carb., tech., bags, lb.	.06 - .06	.06 - .06	.05 - .06
Methanol, 95%, tanks, gal.	.33 - .33	.33 - .33	.33 - .33
97%, tanks, gal.	.34 - .34	.34 - .34	.34 - .34
Synthetic, tanks, gal.	.351 - .351	.351 - .351	.351 - .351
Nickel salt, double, bbl., lb.	.11 - .12	.11 - .12	.12 - .12
Orange mineral, csk., lb.	.091 - .091	.091 - .091	.101 - .101
Phosphorus, red, casks, lb.	.44 - .45	.44 - .45	.45 - .46
Yellow, casks, lb.	.28 - .32	.28 - .32	.28 - .32
Potassium bichromate, casks, lb.	.071 - .08	.071 - .08	.071 - .08
Carbonate, 80-85%, calc. csk., lb.	.07 - .07	.07 - .07	.06 - .07
Chlorate, powd., lb.	.091 - .10	.091 - .10	.08 - .08
Hydroxide (c'atic potash) dr., lb.	.061 - .06	.071 - .07	.071 - .07
Muriate, 80% bgs., ton.	22.00 - 22.00	22.00 - 22.00	37.15 - 37.15
Nitrate, bbl., lb.	.051 - .06	.051 - .06	.051 - .06
Permanganate, drums, lb.	.18 - .19	.18 - .19	.17 - .18
Prussiate, yellow, casks, lb.	.18 - .19	.18 - .19	.16 - .17
Sol ammoniac, white, casks, lb.	.041 - .05	.041 - .05	.041 - .05
Salsoda, bbl., cwt.	1.00 - 1.05	1.00 - 1.05	.90 - .95
Salt cake, bulk, ton.	13.00 - 15.00	13.00 - 15.00	13.00 - 15.00
Soda ash, light, 58%, bags, contract, cwt.	1.23 - 1.23	1.23 - 1.23	1.20 - 1.20
Dense, bags, cwt.	1.25 - 1.25	1.25 - 1.25	1.22 - 1.22
Soda, caustic, 76%, solid, drums contract, cwt.	2.60 - 3.00	2.60 - 3.00	2.50 - 2.75
Acetate, works, bbl., lb.	.041 - .05	.041 - .05	.041 - .05
Bicarbonate, bbl., cwt.	1.85 - 2.00	1.85 - 2.00	1.85 - 2.00
Bichromate, casks, lb.	.051 - .06	.051 - .06	.05 - .05
Bisulphate, bulk, ton.	14.00 - 16.00	14.00 - 16.00	14.00 - 16.00
Bisulphite, bbl., lb.	.03 - .04	.03 - .04	.031 - .04
Chlorate, kegs, lb.	.061 - .06	.061 - .06	.051 - .07
Chloride, tech., ton.	12.00 - 14.75	12.00 - 14.75	12.00 - 14.00
Cyanide, cases, dom., lb.	.151 - .16	.151 - .16	.151 - .16
Fluoride, bbl., lb.	.071 - .08	.071 - .08	.07 - .08
Hyposulphite, bbl., lb.	2.40 - 2.50	2.40 - 2.50	2.40 - 2.50
Metasilicate, bbl., cwt.	3.25 - 3.40	3.25 - 3.40	3.25 - 3.40
Nitrate, bags, cwt.	1.24 - 1.25	1.25 - 1.25	1.25 - 1.25
Nitrite, casks, lb.	.071 - .08	.071 - .08	.071 - .08
Phosphate, dibasic, bbl., lb.	.022 - .024	.021 - .023	.02 - .023
Prussiate, yel. drums, lb.	.11 - .12	.11 - .12	.11 - .12
Silicate (40° dr.) wks. cwt.	.80 - .85	.80 - .85	.80 - .85
Sulphide, fused, 60-62%, dr., lb.	.021 - .03	.021 - .03	.021 - .03
Sulphite, cyrs., bbl., lb.	.021 - .02	.021 - .02	.03 - .03
Sulphur, crude at mine, bulk, ton.	18.00 - 18.00	18.00 - 18.00	18.00 - 18.00
Chloride, dr., lb.	.031 - .04	.031 - .04	.031 - .04
Dioxide, cyl., lb.	.07 - .07	.07 - .07	.061 - .07
Flour, bag, cwt.	1.60 - 3.00	1.60 - 3.00	1.55 - 3.00
Tin Oxide, bbl., lb.	.56 - .56	.56 - .56	.50 - .50
Crystals, bbl., lb.	.38 - .38	.38 - .38	.35 - .35
Zinc chloride, gran., bbl., lb.	.051 - .06	.051 - .06	.051 - .06
Carbonate, bbl., lb.	.091 - .11	.091 - .11	.091 - .11
Cyanide, dr., lb.	.38 - .42	.38 - .42	.38 - .42
Dust, bbl., lb.	.059 - .07	.059 - .07	.07 - .07
Zinc oxide, lead free, bag, lb.	.061 - .061	.061 - .061	.051 - .051
5% lead sulphate, bags, lb.	.061 - .061	.061 - .061	.051 - .051
Sulphate, bbl., cwt.	2.75 - 3.00	2.75 - 3.00	3.00 - 3.25

Oils and Fats

	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl., lb.	\$0.091 - \$0.10	\$0.091 - \$0.10	\$0.091 - \$0.10
Chinawood oil, bbl., lb.	.095 - .095	.099 - .099	.071 - .071
Cocoon oil, Ceylon, tanks, N. Y. lb.	.031 - .031	.021 - .021	.03 - .03
Corn oil crude, tanks, (f.o.b. mill), lb.	.071 - .071	.061 - .061	.041 - .041
Cottonseed oil, crude (f.o.b. mill), tanks, lb.	.07 - .07	.061 - .061	.031 - .031
Linseed oil, raw car lots, bbl., lb.	.093 - .093	.095 - .095	.101 - .101
Palm, Lagos, casks, lb.	.031 - .031	.031 - .031	.04 - .04
Palm Kernel, bbl., lb.	.031 - .031	.031 - .031	.04 - .04
Peanut oil, crude, tanks (mill), lb.	.021 - .06	.061 - .061	.04 - .04
Rapeseed oil, refined, bbl., gal.	.42 - .43	.38 - .39	.50 - .52
Soya bean, tank, lb.	.061 - .061	.061 - .061	.07 - .07
Sulphur (olive foots), bbl., lb.	.071 - .071	.071 - .071	.06 - .06
Cod, Newfoundland, bbl., gal.	.38 - .40	.40 - .40	nom.
Menhaden, light pressed, bbl., lb.	.056 - .053	.053 - .053	.053 - .053
Crude, tanks (f.o.b. factory), gal.	.22 - .22	.22 - .22	.17 - .17
Grease, yellow, loose, lb.	.041 - .041	.041 - .041	.021 - .021
Oleo stearine, lb.	.10 - .08	.081 - .081	.051 - .051
Red oil, distilled, d.p. bbl., lb.	.07 - .07	.07 - .07	.06 - .06
Tallow, extra, loose, lb.	.051 - .051	.041 - .041	.031 - .031



Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl., lb.	\$0.60 - \$0.65	\$0.60 - \$0.65	\$0.60 - \$0.62
Refined, bbl., lb.	.80 - .85	.80 - .85	.80 - .85
Alpha-naphthylamine, bbl., lb.	.32 - .34	.32 - .34	.32 - .34
Aniline oil, drums, extra, lb.	.14 - .15	.14 - .15	.14 - .15
Aniline salts, bbl., lb.	.24 - .25	.24 - .25	.24 - .25
Benzaldehyde, U.S.P., dr., lb.	1.10 - 1.25	1.10 - 1.25	1.10 - 1.25
Benzidine base, bbl., lb.	.65 - .67	.65 - .67	.65 - .67
Benzoic acid, U.S.P., kgs, lb.	.48 - .52	.48 - .52	.48 - .52
Benzyl chloride, tech., dr., lb.	.30 - .35	.30 - .35	.30 - .35
Benzol, 90% tanks, works, gal.	.19 - .20	.19 - .20	.22 - .23
Beta-naphthol, tech., drums, lb.	.22 - .24	.22 - .24	.22 - .24
Cresol, U.S.P., dr., lb.	.11 - .11	.11 - .11	.10 - .11
Crotylic acid, 97% dr., wks, gal.	.50 - .51	.50 - .51	.45 - .46
Diethylaniline, dr., lb.	.55 - .58	.55 - .58	.55 - .58
Dinitrophenol, bbl., lb.	.29 - .30	.29 - .30	.29 - .30
Dinitrotoluen, bbl., lb.	.16 - .17	.16 - .17	.16 - .17
Dip oil 25% dr., gal.	.23 - .25	.23 - .25	.23 - .25
Diphenylamine, bbl., lb.	.38 - .40	.38 - .40	.38 - .40
H-acid, bbl., lb.	.65 - .70	.65 - .70	.65 - .70
Naphthalene, flake, bbl., lb.	.06 - .07	.06 - .07	.04 - .05
Nitrobenzene, dr., lb.	.08 - .09	.08 - .09	.08 - .10
Para-nitraniline, bbl., lb.	.51 - .55	.51 - .55	.51 - .55
Phenol, U.S.P., drums, lb.	.14 - .15	.14 - .15	.14 - .15
Picric acid, bbl., lb.	.30 - .40	.30 - .40	.30 - .40
Pyridine, dr., gal.	1.10 - 1.15	1.10 - 1.15	.90 - .95
Resorcinol, tech., kgs, lb.	.65 - .70	.65 - .70	.65 - .70
Saliylic acid, tech., bbl., lb.	.40 - .42	.40 - .42	.40 - .42
Solvent naphtha, w.w., tanks, gal.	.26 - .26	.26 - .26	.26 - .26
Tolidine, bbl., lb.	.88 - .90	.88 - .90	.88 - .90
Toluene, tanks, works, gal.	.30 - .30	.30 - .30	.30 - .30
Xylene, com., tanks, gal.	.26 - .26	.26 - .26	.26 - .26

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton.	\$22.00 - \$25.00	\$22.00 - \$25.00	\$22.00 - \$25.00
Casein, tech., bbl., lb.	.11 - .13	.12 - .13	.14 - .15
China clay, dom., f.o.b. mine, ton	8.00 - 20.00	8.00 - 20.00	8.00 - 20.00
Dry colors:			
Carbon black, black (wks.), lb.	.04 - .20	.04 - .20	.02 - .20
Prussian blue, bbl., lb.	.35 - .37	.35 - .37	.35 - .36
Ultramarine blue, bbl., lb.	.06 - .32	.06 - .32	.06 - .32
Chrome green, bbl., lb.	.26 - .27	.26 - .27	.27 - .30
Carmines red, tins, lb.	4.00 - 4.40	4.00 - 4.40	3.65 - 3.75
Para toner, lb.	.80 - .85	.80 - .85	.75 - .80
Vermilion, English, bbl., lb.	1.60 - 1.62	1.58 - 1.60	1.35 - 1.40
Chrome yellow, C. P., bbl., lb.	.15 - .16	.15 - .15	.15 - .15
Feldspar, No. 1 (f.o.b. N.Y.), ton	6.50 - 7.50	6.50 - 7.50	6.50 - 7.50
Graphite, Ceylon, lump, bbl., lb.	.07 - .08	.07 - .08	.07 - .08
Gum copal Congo, bags, lb.	.09 - .10	.09 - .10	.06 - .08
Manila, bags, lb.	.09 - .10	.09 - .10	.16 - .17
Damar, Batavia, cases, lb.	.15 - .16	.15 - .16	.16 - .16
Kauri No. 1 cases, lb.	.20 - .25	.20 - .25	.45 - .48
Kieselguhr (f.o.b. N.Y.), ton.	50.00 - 55.00	50.00 - 55.00	50.00 - 55.00
Magnesite, calc, ton.	50.00 - .	50.00 - .	40.00 - .
Pumice stone, lump, bbl., lb.	.05 - .07	.05 - .08	.05 - .07
Imported, casks, lb.	.03 - .40	.03 - .40	.03 - .35
Rosin, H., bbl.	5.75 - .	5.60 - .	5.05 - .
Turpentine, gal.	.33 - .	.46 - .	.46 - .
Shellac, orange, fine, bags, lb.	.35 - .	.35 - .	.24 - .25
Bleached, bonedry, bags, lb.	.32 - .33	.32 - .	.24 - .25
T. N. bags, lb.	.26 - .27	.26 - .27	.13 - .14
Soapstone (f.o.b. Vt.), bags, ton	10.00 - 12.00	10.00 - 12.00	10.00 - 12.00
Talc, 200 mesh (f.o.b. Vt.), ton.	8.00 - 8.50	8.00 - 8.50	8.00 - 8.50
300 mesh (f.o.b. Ga.), ton.	7.50 - 10.00	7.50 - 10.00	7.50 - 11.00
225 mesh (f.o.b. N. Y.), ton.	13.75 - .	13.75 - .	13.75 - .

INDUSTRIAL NOTES

CRANE Co., Chicago, has transferred P. R. Mork from New York to the Chicago office to serve as vice-president in charge of sales, in place of H. W. Seymour, who is on leave of absence. P. R. Berryman will succeed Mr. Mork as manager of the New York branch.

GEARS & FORGINGS, INC., Cleveland, which has been in receivership since April 1, 1932, has effected a reorganization under the name of Ohio Forge & Machine Corp.

YORK ICE MACHINERY CORP., York, Pa., has acquired exclusive rights for the manufacture of Flakice machines and exclusive rights to sell these machines for industrial uses.

PRODUCTIVE EQUIPMENT CORP., Chicago, has appointed Hyman Ledeen as representative in California, Nevada, Utah, Colorado, New Mexico, and Arizona with headquarters at 747 Warehouse St., Los

Angeles. The F. J. Ford Machinery Corp., Denver, will represent the equipment company in Montana, Idaho, Wyoming, and the western Dakotas and Nebraska.

MICHIGAN ALKALI Co. has moved its general sales office in New York to 60 East 42d St.

SOUTHERN PINE CHEMICAL Co., Cleveland, has been formed as the result of a merger of the Wood Chemical Co., the Georgia Pine Turpentine Co., and the Liberty Pine Products Co. Adrian D. Joyce, head of the Glidden Co., is president of the new company.

CHAIN BELT Co., Milwaukee, has appointed Rapp & Hollins, Inc., 7001 North Clark St., Chicago, as its representatives in northern Indiana, northern Illinois, eastern Iowa, and southern Wisconsin.

GLYCO PRODUCTS Co., Inc., Brooklyn, has

moved its sales and purchasing departments to the Flat Iron Bldg., New York.

THE PFAUDLER Co., Rochester, N. Y., has opened an office in the Square Park Bldg., Boston. M. J. Goodwin will be in charge of the new office and will be assisted by J. E. Soares and S. J. Green.

TUBE-TURNS, INC., Louisville, Ky., has moved its New York office to 110 East 42d St. W. P. Curley is the district manager.

CHEMICAL CONSTRUCTION CORP. and CHEMICAL ENGINEERING CORP., New York, have been merged and business in the future will be conducted under the name of the first mentioned corporation.

THE PATTERSON FOUNDRY & MACHINE Co., East Liverpool Ohio, has elected D. M. Wilhelm, secretary of the company. E. M. Underwood will succeed Mr. Wilhelm as sales manager.

NEW CONSTRUCTION

Where Plants Are Being Built in Process Industries

	Current Projects		Cumulative to Date	
	Proposed Work and Bids	Contracts Awarded	Proposed Work and Bids	Contracts Awarded
New England.....	\$29,000		\$1,192,000	\$1,474,000
Middle Atlantic.....	164,000	\$1,004,000	4,661,000	4,198,000
South.....	28,000		13,266,000	7,845,000
Middle West.....	236,000	209,000	9,043,000	1,986,000
West of Mississippi.....	278,000	28,000	15,866,000	909,000
Far West.....	20,000		3,372,000	1,396,000
Canada.....	616,000		4,196,000	1,896,000
Total.....	\$1,371,000	\$1,241,000	\$51,536,000	\$19,704,000

PROPOSED WORK BIDS ASKED

Alum Plant—Ontario Clay Corp., Ltd., F. S. Stratford, Mgr., 205 Vaughan Rd., Toronto, Ont., contemplates the construction of a plant for the manufacture of alum. This will be built at Sault Ste. Marie or Kapuskasing and will be the first of its kind in Canada. Estimated cost \$38,000.

Chemical Plant—American Cyanamid & Chemical Co., 30 Rockefeller Plaza, New York, N. Y., plans to rebuild its plant at Latrobe, Penn., recently damaged by fire with a loss of \$50,000.

Chemical Plant—Youngs Chemical Laboratories, Baltimore, Md., and c/o Miller-Murray & Co., 444 Madison Ave., New York, N. Y., plans alterations to its plant, distribution system and equipment, at Baltimore, Md. Project will probably mature in February. Estimated cost with equipment \$28,000.

China Factory—Edwin M. Knowles China Co., Newell, W. Va., plans the construction of a 2 story addition to its factory here.

Dry Ice Plant—Frozen Carbonic Corp., Neville Island, Pittsburgh, Pa., is having plans prepared by Hannah & Sterling, Archts., Grant Bldg., Pittsburgh, for the construction of a 50x83 ft. dry ice plant. The Company also plans gas retorts and lime kilns.

Evaporator Building—Hiram Walker & Sons, Peoria, Ill., are having plans prepared by Smith, Hinchman & Grylls, Archts. & Engrs., Marquette Bldg., Detroit, Mich., for the construction of a 3 story, 62x70 ft. brick, steel and reinforced-concrete evaporator building in connection with distillery plant. Estimated cost \$50,000.

Gas Plant—City, Palo Alto, Calif., is having plans prepared for a butane gas plant, auxiliary to municipal gas plant, to include two fuel containers, compressors, heat exchangers and regulators, and small building to house plant. L. H. Anderson is director of Utilities. Estimated cost \$20,000.

Gas Plant—Henry P. Rothwell, Gillette, Wyo., has applied to the State Public Utilities Commission for certificate of convenience and necessity to construct gas plant and 25 mi. pipe line.

Laboratory—Mead Paper Corp., Chillicothe, Ohio, plans the construction of a laboratory. Estimated cost \$60,000.

Laboratory—Museum Estates, Inc., c/o Merlis Real Estate Co., 280 Bway., New York, N. Y., plans to alter the building at 178 Washington St., New York, into a laboratory and storage building to be leased to the National Aniline & Chemical Co., 40 Rector St., New York. Estimated cost including equipment will exceed \$28,000.

Laboratory—State Highway Comn., J. D. Adams, Chn., Indianapolis, Ind., is having plans prepared for the construction of a testing laboratory.

Laboratory—Owner, c/o George A. Cornet, Archt., 14 Central Ave., Lynn, Mass., plans the construction of a brick and concrete laboratory and garage. Estimated cost \$28,500.

Laboratory—University of New Mexico, c/o J. J. Dempsey, Pres., Board of Regents, Albuquerque, N. M., is having plans prepared by J. G. Meem, Archt., Sunmount, Santa Fe, for the construction of a laboratory and administration building. F.W.A. funds have been granted for work. Estimated cost \$250,000.

Refinery—Canadian Oil Co., Cloyd A. Hale, Supt., Petrolea, Ont., Can., plans the construction of new topping and cracking units, vapor recovery plant, tube still with steel tower 90 ft. high, and 12 ground storage tanks of 2,000 to 5,000 bbl. capacity each. The company is interested in prices of complete equipment. Estimated cost \$350,000.

Refinery—Gulf Refining Co., 7th and Grant Sts., Pittsburgh, Pa., will soon award the contract for a 2 story, brick and reinforced concrete storage building, 1 story drum and container washing building, 1 story distribution building and small boiler house addition, at its plant at 322 Beekman St., Cincinnati, Ohio. Estimated cost \$30,000.

Oil Refinery—Kent Refining Co., Grand Rapids, Mich., plans to construct a crude oil refinery near Grand Haven, Mich. Estimated cost \$30,000.

Oil Refinery—McClanahan Refining Co., Mt. Pleasant, Mich., plans to construct an oil refinery to have a daily capacity of 1,000 bbl., at Wheeler, Mich.

Paint Factory—Cadillac Paint Co., 433 Leland St., Detroit, Mich., plans to alter and repair its factory here. Estimated cost \$40,000.

Sulphite Plant—Ontario Paper Co., Ltd., Montreal, Que., Can., is preparing plans for the construction of a sulphite and ground pulp plant on the Outander River to have a daily capacity of 300 tons.

Cyanidation Plant—Noranda Mines, Ltd., 804 Royal Bank Bldg., Toronto, Ont., Can., plans the construction of a cyanidation plant. Estimated cost \$200,000 of which \$50,000 will be spent for new equipment.

CONTRACTS AWARDED

Alcohol Plant—U. S. Industrial Alcohol Co., Curtis Bay, Baltimore, Md., awarded contract general remodeling of plant to Barney Ahlers Corp., 110 West 40th St., New York, N. Y. Estimated cost \$150,000.

Factory—Hercules Powder Co., Inc., Wilmington, Del., plans the construction of a plant at Parlin, N. J., for the manufacture of a new protective coating material called "Tornesit." This is a chlorinated rubber product that is rapidly finding use in the protective coating industry because of its great resistance to acids, alkalies, fumes and other destructive elements. This plant will be the first of its kind in this country replacing the material now being imported from Germany. Work will be done under separate contracts.

Foundry—Aluminum Co. of America, J. P. Dearasaugh, Constr. Engr., 2210 Harvard Ave., Cleveland, Ohio, awarded structural steel contract for foundry to Republic Structural Iron Works, East 51st St., Cleveland. Estimated cost \$35,000.

Gas Plant—City, Bushnell, Ill., awarded contract for gas plant and distribution system, to C. I. Tenney Engineering Co., Rand Tower, Minneapolis, Minn., \$62,300.

Gas Plant—City, Bushville, Ill., awarded contract for gas plant and distribution system, to Henry Rees & Sons, Quincy, Ill., \$58,400.

Glass Factory—Glenshaw Glass Co., Glenshaw, Pa., awarded contract for box factory, machine and mold shops, to Pittsburgh Engineering Foundry & Construction Co., 39th St. and A.V. R.R., Pittsburgh.

Laboratory—General Aniline Works, Inc., Grasselli, N. J., awarded general contract for laboratory and warehouse to White Construction Co., 95 Madison Ave., New York, N. Y. Total estimated cost \$150,000.

Laboratory—State Highway Dept., Trenton, N. J., awarded contract for laboratory at Fernwood, near Trenton, to A. A. LaFountain, Beech St., Hackensack, N. J., \$61,700.

Laboratory—U. S. Government, Treasury Dept., Wash., D. C., awarded contract installing scientific laboratory building in Extensible Building, Dpt. of Agriculture, to E. H. Sheldon & Co., Muskegon, Mich., \$389,730; making miscellaneous changes in or to the building, construction of constant temperature rooms, etc., extending mechanical equipment, to Harwood-Nebel Construction Co., Inc., 2539 Pennsylvania Ave., Wash., D. C., \$167,900.

Refinery—Home Oil Refining Co., Mount Vernon, Ohio, has awarded the contract for remodeling its refinery at Great Falls, Mont., to Ralph M. Parsons Co., Mt. Vernon. Construction will include latest type cracking unit designed by Parsons to operate the Dubbs cracking process. Unit will be two-coil selective cracking type, of 1,000 bbl. capacity, and will be equipped with stabilizer, an absorber and special treating system. Additional boilers and equipment for vacuum distillation of asphalt will also be installed.

Sugar Refinery—Central Sugar Co., D. W. McMillen, Mgr., Decatur, Ind., awarded contract for soy bean factory to Calland & Madrox, Decatur. New equipment, including dryers, expellers and filler processors will be needed. Estimated cost \$28,500.

Shoe Polish Plant—Chieftain Manufacturing Co., Clinton and O'Donnell Sts., Baltimore, Md., awarded contract 3 story, 75x75 ft. addition to plant for the manufacture of shoe polishes, to Engineering Contracting Co., 5044 St. Paul St., Baltimore.

Tunnel Kiln—C. C. Thompson Pottery Co., East Liverpool, Ohio, awarded contract for glost tunnel kiln at plant on River Road, to Robertson Co., Hanna Bldg., Cleveland, Ohio. Estimated cost \$25,000.

Raw water (22 grains)	750,000 gal.	Chlorine 0.75 lb. Electricity 50 kw-hr. Direct labor 24 man-hr	To produce 725,000 gal. per day
Hydrated lime	2,145 lb.		
Aluminum sulphate	150 lb.		
Activated carbon	5 lb.		